IN THE UNITED STATES BANKRUPTCY COURT
FOR THE SOUTHERN DISTRICT OF TEXAS
CORPUS CHRISTI DIVISION

In re:	§	**Case No. 05-21207**
	§	
ASARCO LLC, *et al.*,	§	**Chapter 11**
	§	
Debtors.	§	**Jointly Administered**
	§	

PROFFER OF DIRECT TESTIMONY OF
SHAHROKH ROUHANI, Ph.D., P.E.

Introduction

The following information is a true and accurate statement of my testimony if I were called as a witness in open court in this case. This proffer summarizes the conclusions offered in the expert report of Dr. Rouhani as well as the testimony offered by Dr. Rouhani in his deposition on July 23, 2007.

A. Brief Summary of Opinions

I was retained by Union Pacific to offer an expert opinion on the spatial structure of soil lead concentrations measured by the U.S. Environmental Protection Agency ("EPA") in various parts of the Omaha Lead Site ("OLS"). In my report,[1] I concluded that the special structure of available soil lead data indicates that the impact of the smelter is confined to a small, interior portion of the OLS. This conclusion is based upon thorough GIS and geostatistical analyses of available data and confirmed by the following three independent lines of evidence:

- Directional variograms of yard data, which indicate localized soil lead concentrations inconsistent with contamination from a single point source;
- The age of structures in the OLS, which indicate yard contamination from lead paint; and
- Data taken from in and around the OLS, which demonstrates a consistent normal distribution of lead concentrations devoid of highly elevated values, despite the parks' proximity to the OLR.

B. Expert Qualifications

I am an environmental scientist, professional engineer, tenured associate professor at Georgia Institute of Technology, and the founder/president of NewFields Companies, LLC, a nationwide partnership of environmental experts. I hold a Ph.D. in environmental sciences and an M.S. in environmental engineering, both from Harvard University, as well as a B.S. in civil engineering and a B.A, in economics from the University of California, Berkeley. I have conducted statistical and geostatistical research addressing a variety of sampling and analysis issues and has authored and co-authored several publication, including a series of American Society for Testing and Material ("ASTM") standard guides for the application of geostatistics in environmental site investigations, a three-volume guidance document for background data analysis, and an up-coming EPA guidance on soil cleanup strategies at CERCLA sites. I am active in several professional societies and have served on the editorial board of several environmental publications. I was the National Science Foundation visiting scientist at *Centre de Géostatistique, Ecole Nationale Supérieure des Mines de Pairs* in France. My curriculum vitae is attached.[2]

C. Statement of Opinions

1. The facts or data I have relied upon are of a type reasonably relied upon by experts in the field of geographical information systems ("GIS") and geostatistics in forming opinions or inferences upon this subject. The most commonly used geostatistical tool for the analysis of spatial structures is the variogram, which is a quantitative measure of the correlation between data points along a given direction as a function of their separation distance. In this study, I calculated directional variograms in various parts of the OLS consistent with the

procedures provided in the ASTM Standard Guide for Analysis of Spatial Variation in Geostatistical Site Investigations.[3] Demonstrative exhibits showing the variograms and my related analysis, all of which were attached to my report, are attached.

2. The spatial structure of the available soil data indicates that the impact of the smelter is confined to a small, interior portion of the OLS. If the smelter were the primary source of lead contamination in a given area, then the variogram of lead data in that area would display a trend along a direction emanating from the smelter. In Omaha, however, background levels of lead concentrations or localized sources manifest themselves by a combination of pure-nugget-effect[4] (where the data are devoid of any spatial structure) and/or hole-effect[5] (where the related data are clustered in isolated pockets) variograms, respectively.

<u>Line of Evidence 1: Directional Variograms</u>

3. To quantitatively assess the potential extent of the smelter impact, the yard data around the smelter was divided into a number of areas, referred to as "windows." In all investigated windows, directional variograms display large nugget-effect and/or hole-effect components. Presence of such components implies ubiquitous random and localized occurrences of soil lead concentrations. Random and localized occurrences of soil lead concentrations are typical of older urban areas with multiple point sources, and an historical use of lead-based paint, leaded gasoline, and lead-arsenate pesticides.

4. The directional variograms in two windows indicate the presence of trends towards the smelter. The proximity of these windows to the smelter, their positions along the prevailing wind directions from the smelter, as well as their elevated average yard lead data, imply that historical area emissions from the smelter can be partially responsible for detected

lead concentrations. However, the presence of large nugget effects indicates impacts by localized sources other than the smelter.

5. The directional variograms in other windows do not support the dominant presence of trends toward the smelter.

6. The quantitative directional variogram analyses confirm that the extent of impact from the smelter is confined to a small, interior portion of the OLS, situated in the immediate vicinity of the smelter. These findings clearly reject the hypothesis that historical air emissions from the smelter are the primary source of detected soil lead in the OLS.

Line of Evidence 2: Age of Structures

7. A review of available yard data indicates that, on average, properties closer to the smelter have higher lead concentrations than those situated farther away. This information can be easily misinterpreted as evidence for the wide-spread impact of the smelter. However, these patterns are closely related to the age of the structures within the investigated properties. On average, properties with older structures have higher lead concentrations in their yard samples. On average, properties with older structures have higher lead concentrations in their drip zone samples. On average, properties with older structures have paints with higher lead contents. On average, properties closer to the smelter contain older structures than those situated farther away. The observed pseudo-trend toward the smelter can be partially, if not wholly, attributed to the age of the structures.

Line of Evidence 3: Park Data

8. The EPA database contains a number of samples collected from parks in and around the OLS ("park data").[6] Park data are likely to be less impacted by nearby structures

when compared to samples collected in much smaller residential yards. It can be argued that park data, on average, have been exposed to fewer natural and anthropogenic variations than samples collected in the much smaller residential yards. Therefore, park data can be used as suitable representations of the impact of historical air depositions from the smelter.

9. The spatial distribution of park data clearly rejects the presence of a radial pattern emanating from the smelter. The two highest park data are situated more than 3 km from the smelter and adjacent to Highway 75. Such a pattern is typical of historical impacts of leaded gasoline.

10. The probability plot of park data demonstrates a consistent normal distribution of lead concentrations devoid of highly elevated values. Such a distribution is inconsistent with and therefore clearly rejects excessive air deposition impacts from a point source.

11. The above results clearly reject the hypothesis that historical air emissions from the smelter have impacted large potions of the OLS.

D. Exhibits to be Introduced in Support of Direct Testimony

The Exhibits offered as part of my direct testimony are listed in endnotes and copies of the Exhibits have been submitted by Union Pacific.

Pursuant to 28 U.S.C. § 1746, I declare under penalty of perjury that the foregoing is true and correct. Executed this 1st day of August 2007 in Denver, Colorado.

S. Rouhani

Shahrokh Rouhani, Ph.D., P.E., Expert Witness

[1] Shahrokh Rouhani, Spatial Analysis of Soil Lead Data, Omaha Lead Site, Prepared for Union Pacific Railroad Company (May 8, 2007). (UPRR037674/7715).

[2] Curriculum vita of Dr. Shahrokh Rouhani.

[3] ASTM Standard Guide for Analysis of Spatial Variation in Geostatistical Site Investigations, D 5922-96 (ASTM, 1996)

[4] See Figure 2(c) to Rouhani Report (May 8, 2007). (UPRR037687).

[5] See Figure 2(d) to Rouhani Report (May 8, 2007). (UPRR037687)

[6] EPA Database of Soil Lead Concentrations (Nov. 2006) (UPRR037553).

INDEX OF ATTACHED DEMONSTRATIVE EXHIBITS—SHAHROKH ROUHANI

No.	Description	Dated
A.	Professional Qualifications of Shahrokh Rouhani	May 2007
1.	Figure 1—Omaha Lead Site	May 2007
2.	Figure 2—Typical Variograms	May 2007
3.	Figure 3—Variogram Windows and Average Construction Year of Structures in Investigated Properties Displayed Within 1-km Radial Transects from the Smelter	May 2007
4.	Figure 4—Monthly Average Wind Rose Diagrams • Figure 4(a)—January Through June • Figure 4(b)—July Through December	May 2007
5.	Figure 5—Probability Plot and Directional Variograms of Yard Lead Data • Figure 5(a)—Window NW-A • Figure 5(b)—Window NW-B • Figure 5(c)—Window NW-C • Figure 5(d)—Window NW-D • Figure 5(e)—Window W-A • Figure 5(f)—Window W-B • Figure 5(g)—Window SW-A • Figure 5(h)—Window SW-B • Figure 5(i)—Window S-A • Figure 5(j)—Window S-B • Figure 5(k)—Window S-C	May 2007
6.	Figure 6—Age of Structures Versus Yard Lead Data	May 2007
7.	Figure 7—Age of Structures Versus Drip Zone Lead Data	May 2007
8.	Figure 8—Age of Structures Versus Lead Paint Data	May 2007
9.	Figure 9—Park Lead Data	May 2007

9 Curriculum Vita

Shahrokh Rouhani, Ph.D., P.E.
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1349 West Peachtree Street, Suite 2000, Atlanta, GA 30309
Tel: (404)347-9050; Fax: (404)347-9080
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EDUCATIONAL BACKGROUND

Ph.D.	1983	Harvard University	Environmental Sciences
S.M.	1980	Harvard University	Engineering
B.A.	1978	University of California, Berkeley	Economics
B.S.	1978	University of California, Berkeley	Civil Engineering

PROFESSIONAL EXPERIENCE

President	NewFields, Inc.	1995 - Present
President	NewFields Companies, LLC	2002 - Present
Adjunct Professor	School of Civil and Environmental Engineering Georgia Institute of Technology	1996 - Present
Editorial Board Member	*Environmental Forensics* Association for Environmental Health and Sciences	2003 - Present
Associate Professor	School of Civil and Environmental Engineering Georgia Institute of Technology	1990 - 1996
Senior Consultant	Dames & Moore Atlanta, GA	1990 - 1995
Chairman	National Ground Water Hydrology Committee, Hydraulics Division, American Society of Civil Engineers	1991 - 1992
Expert Member	ASTM/EPA/USGS/DOD Geostatistics Standardization Committee	1991 - Present
Associate Editor	*Water Resources Research* American Geophysical Union	1989 - 1994
Assistant Professor	School of Civil Engineering Georgia Institute of Technology	1983 - 1990
Chairman	Task Committee on Geostatistical Techniques in Geohydrology, American Society of Civil Engineers	1987 - 1989

National Science Foundation Visiting Scientist	Centre de Géostatistique, Ecole Nationale Supérieure des Mines de Paris, France	1987 - 1988

PROFESSIONAL REGISTRATION

Licensed Professional Engineer Georgia (Registration Number 19369)

CURRENT FIELD OF INTEREST

Geostatistics
Decision Analysis
Environmental Statistics
Geostatistical and Stochastic Hydrology
Surface and Groundwater Hydrology

HONORS AND AWARDS

Tau Beta Pi (National Engineering Honor Society)	1977
Chi Epsilon (Civil Engineering Honor Society)	1978
Phi Beta Kappa (National Honor Society for Students in Social Sciences)	1978
Watson Award, Division of Applied Sciences, Harvard University	1979-82
Sigma Chi (Scientific Research Society)	1987
1990 Who's Who (Rising Young Americans)	1990
ASCE Task Committee Excellence Award, Hydraulics Division (S. Rouhani, Chairman of ASCE Task Committee on Geostatistical Techniques in Geohydrology)	1991
Dictionary of International Biography - 22nd Edition	1992
Two Thousand Notable American Men, First Edition	1992
Who's Who in America	1995-Present

NEWFIELDS REPRESENTATIVE PROJECT EXPERIENCE

Statistical Source Contamination Identification, Coleman-Evans Superfund Site, Whitehouse, Florida – On behalf of EPA, extensive historical soil data were analyzed in order to determine the extent of ambient versus site-related dioxins.

Geostatistical Source Impact Delineation, Mission Valley, San Diego, California – Extensive BTEX, MTBE groundwater database was geostatistically analyzed in order to define the extent of site-related plumes.

Anniston Lead Site – Lead negotiation, cleanup, and sampling efforts at Anniston Lead Site. These efforts included statistical and geostatistical analyses of soil lead and PCB data in order to verify the extents of zones of investigations.

Groundwater Chlorinated Solvent Contamination Class Certification Evaluation - Extensive historical groundwater data from a region in Ohio were compiled and analyzed in order to evaluate the proposed class certification in a federal case of chlorinated solvent contamination in a mixed urban/rural area. For this purpose, multivariate statistical and geostatistical techniques were employed, which clearly indicated the presence of multiple sources unrelated to the defendants' activities.

Groundwater MTBE Contamination Class Certification Evaluation – Available historical groundwater MTBE data from a region in Connecticut were compiled and analyzed in order to evaluate the proposed class certification in a state case of chlorinated solvent contamination in a suburban area. For this purpose, multivariate statistical and geostatistical techniques were employed, which clearly indicated the limited extent of contamination associated with the defendant's facility.

United Nations Compensation Commission Expert Assessment **–** Extensive sediment and soil data provided associated with the environmental damages from post-1991 Kuwait conflict were statistically and geostatistically analyzed. These analyses were conducted as part of the UNCC technical review of submitted claims.

St. Johns River Water Management District Minimum Flow Determination – Developed an innovative combined hydrodynamic and statistical approach to establish minimum flow levels for Blue Spring based on protection of manatees winter refuge criteria.

St. Johns River Water Management District Geostatistical Peer Review – Lead technical reviewer for numerous projects at SJRWMD, including optimization of groundwater monitoring networks, mapping of potentiometric surfaces, groundwater flow modeling, assessment of seagrass monitoring protocols, Lake Apopka soil data analysis, and time series analysis of groundwater and lake monitoring data.

South Florida Water Management District Lower West Coast Potentiometric Mapping – Technical lead on statistical and geostatistical analysis of available seasonal, multi-layer groundwater elevation data for Lower West Coast potentiometric Mapping.

US Navy CURT (Clean Up Review Team). - Technical lead on strategic review of US Naval environmental projects worldwide. In this role Dr. Rouhani has assisted US Navy to review more than 750 projects and identify more than $100 million in cost-avoidance.

US EPA Project on Multivariate Geostatistical Trend Detection and Network Design for Acid Deposition Data. Principal investigator for development of a multivariate geostatistical technique for trend detection in acid deposition data and spatial evaluation of current national network, known as NAPD/NTN.

US Department of Energy Project on Application of Geostatistical Methods to Savannah River Site Environmental and Geotechnical Investigation - Principal investigator for development and application of advanced procedures for evaluation of the adequacy of groundwater quality data at a waste site, as well as development of geostatistical estimation/simulation procedure in support of seismic modeling of the site.

Mole Pier, San Diego Naval Station - Projector Director for the data evaluation and analysis of the anticipated $40 million dollar clean up project.

Allen Harbor Landfill, North Kingstown, RI - Projector Director for updating superfund remedy selection. The original cap remedy was cost estimated at $14 million.

Spatial Statistical Assessment. Performed an extensive soil and groundwater analysis at a CERCLA site in Baton Rouge, Louisiana. Site was geostatistically analyzed in order to

perform four major tasks: (1) to characterize three-dimensional soil contamination mapping, (2) to calculate block-area groundwater contamination levels, (3) to produce sampling plans for subsequent measurements, and (4) to provide most accurate information on the spatial distribution of parameters of the groundwater flow/transport model of the site.

Groundwater statistical optimization. Assessement of soil and groundwater at manufacturing facility in Athens, Georgia. Geostatistics was used to (1) characterize the groundwater contamination in a three-dimensional framework, and (2) identify areas which exhibit either data gaps, or potentially elevated contaminations. Geostatistically produced kriged and quantile maps were used to characterize the site contamination, as well as identify location for subsequent sampling activities.

Statistical risk evaluation. Principal investigator for risk assessment study of a major development site in Detroit Michigan. Geostatistics was used to estimate surface soil block contamination, evaluate the adequacy of the existing surficial measurements, and design an information-efficient deep soil sampling plan.

Soil characterization planning and optimization. An innovative phased geostatistical sampling plan was developed to characterize soil and groundwater contamination at a RCRA industrial site in South Carolina.

Groundwater transport modeling for remedial evaluation. Determined the effectiveness of a proposed list of groundwater remedial alternatives at a CERCLA site through the use of U.S. Geological Survey groundwater flow/transport model, MOC-2D. The results of model provided a realistic assessment of long-term potential efficiency of the various pump-and-treat alternatives.

Risk evaluation of contaminated soils. Existing soil data from an abandoned industrial site in Michigan were geostatistically analyzed to perform two tasks: (1) to characterize the site contamination in a multi-layer framework, and (2) identify areas which exhibit either data gaps, or potentially elevated contaminations.

Phased sampling planning. Existing soil data from an industrial landfill in West Pittsburg, California were analyzed in order to produce an elaborate phased sampling plan. The plan included a series of interconnected rule-based stages that allow the decision-maker to pursue the sampling activity in an efficient manner, using a variety of geostatistical, statistical, and deterministic techniques.

Statistical assessment of migration potential. For a project in Memphis, Tennessee, existing data on the thickness of a critical near-surface aquitard were geostatistically analyzed in order to determine zones of potential leakage to the lower aquifer.

GEORGIA TECH REPRESENTATIVE RESEARCH EXPERIENCE

Title:	Optimal Sampling of Stochastic Processes
Sponsor:	National Science Foundation
Duration:	(6/1/85 to 10/30/87)
Subject:	In this project, Dr. Rouhani developed optimal sampling and monitoring techniques for ground water quantity and quality investigations, based on advanced geostatistical procedures. It was shown that using such techniques can yield economically efficient sampling plans.

Title:	Optimal Schemes for Ground Water Quality Monitoring in the Shallow Aquifer, Dougherty Plain, Southwestern Georgia
Sponsor:	U.S. Geological Survey
Duration:	(4/1/86 to 3/31/87)
Subject:	In this project, Dr. Rouhani developed a flexible geostatistical procedure for planning a ground water quality monitoring network in Dougherty Plain, Georgia. The proposed network acts as a warning system for the protection of the Floridan Aquifer system which is a major source of water in south Georgia and Florida.

Title:	Advanced Geostatistical Studies at the Centre de Geostatistique, Ecole des Mines de Paris.
Sponsor:	National Science Foundation
Duration:	(9/1/87 - 2/18/89).
Subject:	Through this project Dr. Rouhani developed new techniques for statistical analysis of space-time data, including air pollution and ground water contamination data. The budget of this project was the highest amount awarded by the NSF's "U.S. - Industrialized Countries Program for the Exchange of Scientists and Engineers" in 1987.

Title:	Geostatistical Evaluation of Flow Parameters
Sponsor:	U.S. Geological Survey
Duration:	(4/1/90 - 3/31/91)
Subject:	Dr. Rouhani developed techniques for efficient estimation of ground water flow parameters based on available hydrogeological field data.

Title:	Multivariate Geostatistical Trend Detection and Network Design for Acid Deposition Data
Sponsor:	U.S. Environmental Protection Agency
Duration:	(3/1/1991 -9/30/1991)
Subject:	Dr. Rouhani developed a multivariate geostatistical technique for trend detection in acid deposition data and spatial evaluation of current national network, known as NAPD/NTN.

Title:	Multilayer Geostatistical Ground Water Flow and Transport Modeling
Sponsor:	HazLab, Inc.
Duration:	(6/20/92 -12/30/92)
Subject:	Dr. Rouhani developed a combined deterministic/geostatistical groundwater flow/transport model.

Title:	Velocity/Lithology Model Database, Statistical Models of Soil Columns Velocity, and Maps of Model Layers
Sponsor:	Westinghouse Savannah River Company / U.S. DOE
Duration:	(1/1/1993-6/30/1993)
Subject:	Dr. Rouhani developed a relational database and conducted extensive geostatistical analyses of seismic data.

Title:	Application of Geostatistical Methods to SRS Groundwater Monitoring and Environmental Risk
Sponsor:	Westinghouse Savannah River Company / U.S. DOE
Duration:	(7/1/1993-10/15/1993)

Subject: Dr. Rouhani developed procedures for evaluation of the adequacy of groundwater quality data at a waste site.

Title: H-Area/ITP Geostatistical Assessment of In-situ and Engineering Properties
Sponsor: Westinghouse Savannah River Company / U.S. DOE
Duration: (1/1/1994-6/30/1995)
Subject: Dr. Rouhani will develop geostatistical estimation/simulation procedure in support of seismic modeling of the site.

PUBLICATIONS

Published Books and Parts of Books

- Rouhani, S., and T.J. Hall, "Geostatistical Schemes for Groundwater Quality Management in Southwest Georgia," in *Pollution, Risk Assessment, and Remediation in Groundwater Systems*, pp. 197-223, R.M. Khanbilvardi and J. Fillos, Eds., Scientific Publications Co., Washington, DC, 1987.
- Rouhani, S., and R. Kangari, "Landfill Site Selection," in *Expert Systems: Applications to Urban Planning*, Ch. 10, T.J. Kim *et al.*, Eds., Springer-Verlag, 1989.
- Lennon, G.P., and S. Rouhani, Eds., *Ground Water*, Proceedings of the ASCE International Symposium on Ground Water, ASCE, 1991.
- Rouhani, S., R. Srivastava, A. Debarats, M. Cromer, and I. Johnson, Eds., "*Geostatistics for Environmental and Geotechnical Applications*," STP 12 83, ASTM, 1996.

Standards and Guidance Documents (Main Author/Contributing Author)

- American Society of Testing and Materials (ASTM), *Standard Guide for Reporting Geostatistical Site Investigations*, D5549-94, 1994.
- American Society of Testing and Materials (ASTM), *Standard Guide for Analysis of Spatial Variation in Geostatistical Site Investigations*, D5522-96, 1996.
- American Society of Testing and Materials (ASTM), *Standard Guide for Selection of Kriging Methods in Geostatistical Site Investigations*, D5522-96, 1996.
- American Society of Testing and Materials (ASTM), *Standard Guide for Selection of Simulation Approaches in Geostatistical Site Investigations*, D5524-96, 1994.
- Department of Navy (DON), *Guidance for Environmental Background Analysis, Volume I: Soil*, NFESC User's Guide, UG-2049-ENV, April 2002.
- Department of Navy (DON), *Guidance for Environmental Background Analysis, Volume II: Sediment*, NFESC User's Guide, UG-2054-ENV, April, 2003.
- Department of Navy (DON), *Guidance for Environmental Background Analysis, Volume III: Groundwater*, Final, April, 2004.
- United States Environmental Protection Agency (US EPA), *Guidance for Soil Cleanup Strategies*, Draft, 2003.

Published Journal Papers (refereed)

- Rouhani, S., "Variance Reduction Analysis", *Water Resources Research*, Vol. 21, No. 6, pp. 837-846, June, 1985.
- Rouhani, S., "Comparative Study of Ground Water Mapping Techniques", *Journal of Ground Water*, Vol. 24, No. 2, pp. 207-216, March-April 1986.
- Rouhani, S., and Fiering, M.B., "Resilience of a Statistical Sampling Scheme," *Journal of Hydrology*, Vol. 89, No. 1, pp. 1-11, December, 1986.
- Rouhani, S., and Kangari, R., "Landfill Site Selection: A Microcomputer Expert System," *International Journal of Microcomputers in Civil Engineering*, Vol. 2, No. 1, pp. 29-35, March, 1987.

- Rouhani, S., and Hall, T.J., "Geostatistical Schemes for Groundwater Sampling," *Journal of Hydrology*, Vol. 103, 85-102, 1988.
- Rouhani, S., and Cargile, K.A., "A Geostatistical Tool for Drought Management," *Journal of Hydrology*, Vol. 106, 257-266, 1989.
- ASCE Task Committee on Geostatistical Techniques in Geohydrology (S. Rouhani, Chairman and Principal Author), "Review of Geostatistics in Geohydrology, 1. Basic Concepts," *ASCE Journal of Hydraulic Engineering*, 116(5), 612-632, 1990.
- ASCE Task Committee on Geostatistical Techniques in Geohydrology (S. Rouhani, Chairman and Principal Author), "Review of Geostatistics in Geohydrology, 2. Applications," *ASCE Journal of Hydraulic Engineering*, 116(5), 633-658, 1990.
- Rouhani, S., and H. Wackernagel, "Multivariate Geostatistical Approach to Space-Time Data Analysis," *Water Resources Research*, 26(4), 585-591, 1990.
- Rouhani, S. and D.E. Myers, "Problems in Space-Time Kriging of Geohydrological Data," *Mathematical Geology*, 22(5), 611-624, 1990.
- Loaiciga, H.A., R.J. Charbeneau, L.G. Everett, G.E. Fogg, B.F. Hobbs, and S. Rouhani, "Review of Ground-Water Quality Monitoring Network Design," *ASCE Journal of Hydraulic Engineering*, 118(1), 11-37, 1992.
- Rouhani, S., R. Ebrahimpour, I. Yaqub, and E. Gianella, "Multivariate Geostatistical Trend Detection and Network Evaluation of Space-Time Acid Deposition Data, 1. Methodology," *Atmospheric Environment*, 26A(14), 2603-2614, 1992.
- Rouhani, S., R. Ebrahimpour, I. Yaqub, and E. Gianella, "Multivariate Geostatistical Trend Detection and Network Evaluation of Space-Time Acid Deposition Data, 2. Application to NADP/NTN Data," *Atmospheric Environment*, 26A(14), 2615-2626, 1992.
- Casado, L., S. Rouhani, C. Cardelino, and A. Ferrier, "Geostatistical Analysis and Visualization of Hourly Ozone Data," *Atmospheric Environment*, 28(12), 2105-2118, 1994.
- Rouhani, S., Geostatistical Estimation: Kriging, in Rouhani et al., Eds., "*Geostatistics for Environmental and Geotechnical Applications*," STP 12 83, ASTM, 1996.
- Wild, M. R., and S. Rouhani, Effective Use of Field Screening Techniques in Environmental Investigations: A Multivariate Geostatistical Approach, in in Rouhani et al., Eds., "*Geostatistics for Environmental and Geotechnical Applications*," STP 12 83, ASTM, 1996.
- Lin, Y. P., and S. Rouhani, "Geostatistical Analyses for Shear Wave Velocity," *J. of The Geological Society of China*, Vol. 40, No. 1, p 209-223, 1997.
- Lin, Y.P., and S. Rouhani, "Multiple-Point Variance Analysis for Optimal Adjustment of A Monitoring Network," *Environmental Monitoring and Assessment*, 69(3), pp. 239-266, 2001.
- Lin, Y. P., Y. C. Tan, and S. Rouhani, "Identifying Spatial Characteristics of Transmissivity Using Simulated Annealing and Kriging Methods," *Environmental Geology*, 41:200-208, 2001

<u>Published Research Reports</u>

- Rouhani, S., "Toward a More Efficient Farm Level Models," presented at the seminar on water management planning in Pakistan, Development Research Center, World Bank, Washington, DC, *Ford-Pakistan Project Annual Progress Report*, 1980.
- Chaudri, A., S. Rouhani and P.P. Rogers, "Hydrology of Induced Recharge in Indus Basin Pakistan," Department of City and Regional Planning, Harvard University, 1980.
- Rouhani, S., "Toward a More Effective Indus Basin Model, Waterlogging and Salinity Considerations," presented at the Tri-partite meeting in Pakistan, Development Research Center, world Bank, Washington, DC, *Ford-Pakistan Project Annual Progress Report*, 1981.

- Rouhani, S. and T. J. Hall, "Optimal Schemes for Ground Water Quality Monitoring in the Shallow Aquifer, Dougherty Plain, Southwestern Georgia," Technical Completion Report, U.S. Dept. of Interior/USGS Project G-1219(05), ERC 05-87, Environmental Resources Center, Georgia Institute of Technology, Atlanta, Georgia, 49 p., 1987.
- Rouhani, S., "Optimal Sampling of Stochastic Processes," Final Technical Research Report, National Science Foundation, Grant No. ECE-8503897, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Georgia, p. 170,1987.
- Rouhani, S., "L'Analyse de Donnees Geohydrologiques," *De Geostatisticis*, No. 3, pp. 5-6, August, 1988.
- Rouhani, S., "Advanced Geostatistical Studies at the Centre de Geostatistique, Ecole des Mines de Paris," Final Technical Research Report, National Science Foundation, Grant No. INT-8702264, School of Civil Engineering, Georgia Institute of Technology, Atlanta, GA, 129 p., May 1989.
- Rouhani, S., "Geostatistics: Theory, Practice, and Personal Computer Applications," Education Extension, Georgia Institute of Technology, September, 1989.
- Rouhani, S., R. Ebrahimpour, I. Yaqub, and E. Gianella, "Multivariate Geostatistical Trend Detection and Network Evaluation of Space-Time Acid Deposition Data," Final Technical Report, AREAL, U.S. Environmental Protection Agency, Contract 68-D0-0095, RTP, NC, 320 p., October, 1991.
- Rouhani, S., M. J. Maughon, and B. J. Weiss, "Geostatistical Mapping of Ground Water Contaminants," Technical Report, HazLab, Inc., Contract E-20-X18, School of Civil Engineering, Georgia Institute of Technology, Atlanta, January 1993.

Conference Papers (refereed)

- Rouhani, S., "Optimal Groundwater Data Collection, Waterlogging and Salinity Considerations," *Proceedings of the International Seminar on Water Resources Management*, Lahore, Pakistan, No. 3, pp. 167-182, October 1983.
- Rouhani, S., "A Scheme for Water Resources Monitoring in Rural Areas," *Proceedings of the Vth World Congress on Water Resources*, IWRA, Vol. 2, pp. 701-710, June, 1985.
- Kangari, R. and Rouhani, S., "Expert Systems in Reservoir Management and Planning," in *World Water Issues in Evolution, Water Forum '86*, M. Karamouz et al., Eds., Vol. 1, pp. 186-194, American Society of Civil Engineers, New York, 1986.
- Rouhani, S., and R. Kangari, "Expert Systems in Water Resources," *Water for the Future: Hydrology in Perspective*, J. C. Rodda and N.C. Matalas, Eds., pp. 457-462, International Association of Hydrological Sciences, Publication No. 164, 1987.
- Rouhani, S., and T.J. Hall, "Space-Time Kriging of Groundwater Data," in *Geostatistics*, M. Armstrong, Editor, Vol. 2, pp. 639-650, Kluwer Academic Publishers, Dordrecht, Holland, 1989.
- Kangari, R., and Rouhani, S., "Knowledge-Based Systems in Water Resources Management," *Proceedings of the International Conference on Water and Wastewater*, pp. 588-593, Academic Periodical Press, Beijing, China, 1989.
- Rouhani, S., "Geostatistics in Water Resources," *Proceedings of the 1989 Georgia Water Resources Conference*, K. J. Hatcher, Ed., pp. 169-171, Institute of Natural Resources, University of Georgia, Athens, Georgia, 1989.
- Rouhani, S., and M. E. Dillon, "Geostatistical Risk Mapping for Regional Water Resources Studies," *Use of Computers in Water Management*, Vol. 1, pp. 216-228, V/O "Syuzvodproekt", Moscow, USSR, 1989. (Also in Russian: Vol. 2, pp. 234-249.)

PROFESSIONAL ACTIVITIES

- American Geophysical Union: Member, 1981-Present
    - Associate Editor, *Water Resources Research*, 1989-1994.
- American Society of Civil Engineering: Associate Member, 1983-1987; Member, 1987-Present.
    - Chairman, National Ground Water Hydrology Committee (Standing Committee), Hydraulics Division, Oct. 1991-1992.
    - Chairman, ASCE Task Committee on Geostatistical Techniques in Geohydrology, Ground Water Hydrology Technical Committee, American Society of Civil Engineers, Hydraulics Division, Oct. 1987-Sept. 1989.
    - Contact Member, ASCE Task Committee on Groundwater Monitoring Network Design, Probabilistic Approaches to Hydraulics and Hydrology Committee, Hydraulic Division, Oct. 1988- Sept. 1990.
    - Secretary, ASCE Water Resources Committee, American Society of Civil Engineers, Georgia Section, 1988.
    - Special Session Organizer, Special Session on "Development and Applications of Geostatistics in Geohydrology," 1989 ASCE National Conference on Hydraulic Engineering, New Orleans, August 14-18, 1989.
    - Special Session Organizer and Chairman, Special Session on Geostatistics in Geohydrology, 1990 ASCE Water Resources Conference, Fort Worth, April, 1990.
    - Symposium Organizer, International Symposium on Ground Water, 1991 ASCE National Conference on Hydraulic Engineering, Nashville, July, 1991.
- International Water Resources Association: Member, 1985-Present.
- American Water Resources Association: Member, 1986-Present.
- North American Council on Geostatistics, 1987-Present.
- International Geostatistical Association: Member, 1989-Present.
- Association for Environmental Health and Sciences (AEHS): Member, 2003-Present.
    - Member of Editorial Board, *Environmental Forensics*, 2003-Present.

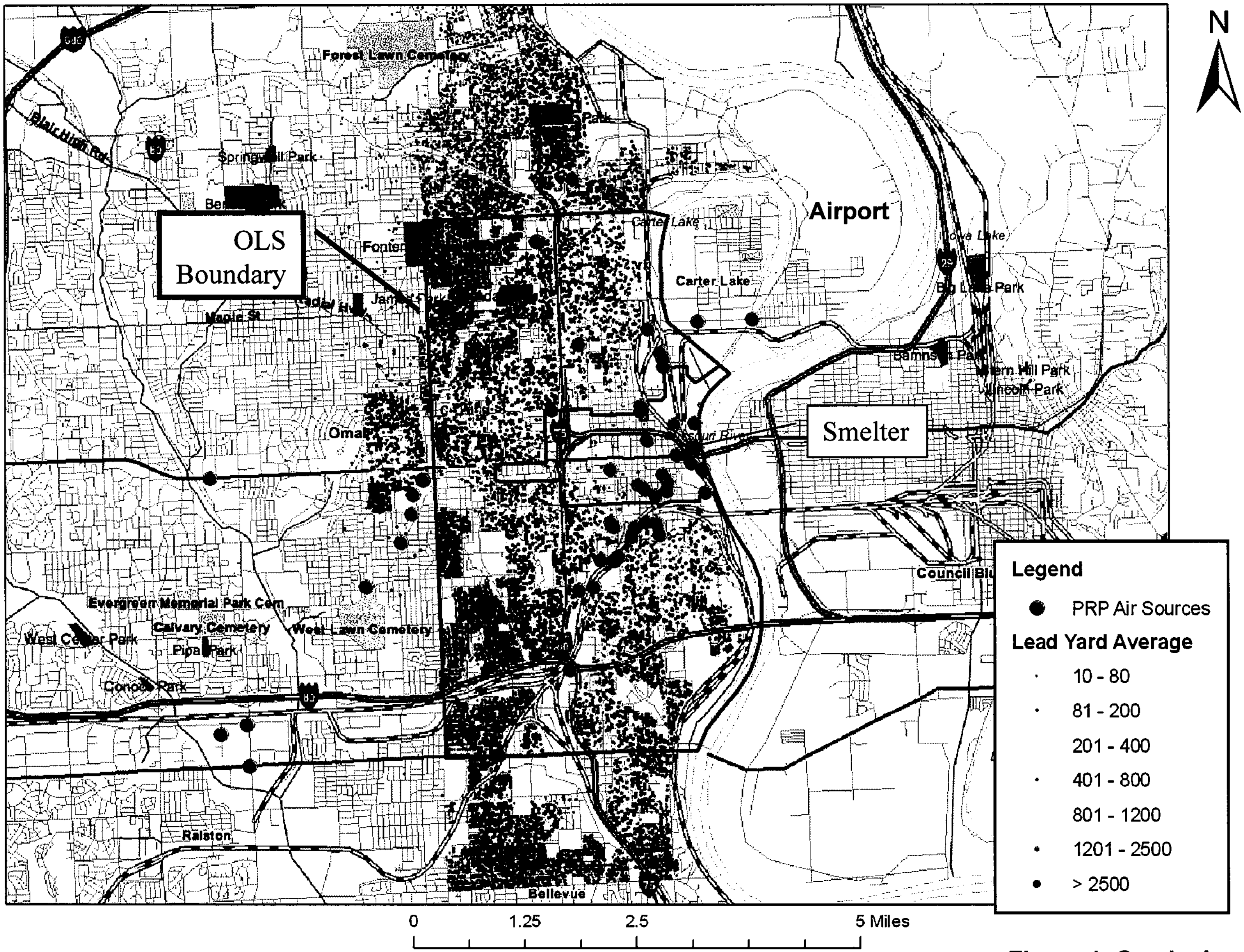


Figure 1. Omaha Lead Site

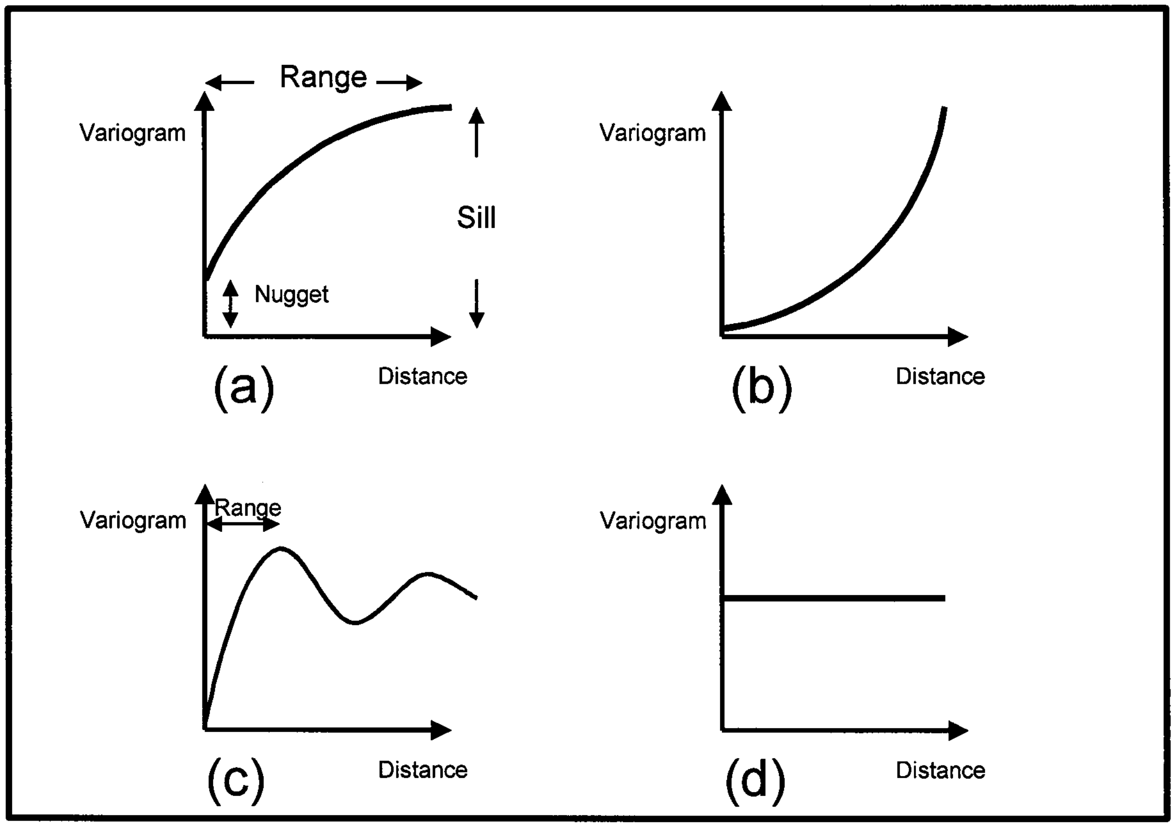


Figure 2
Typical Variograms:
(a) Structured variogram
(b) Trend
(c) Hole-effect
(d) Pure nugget effect

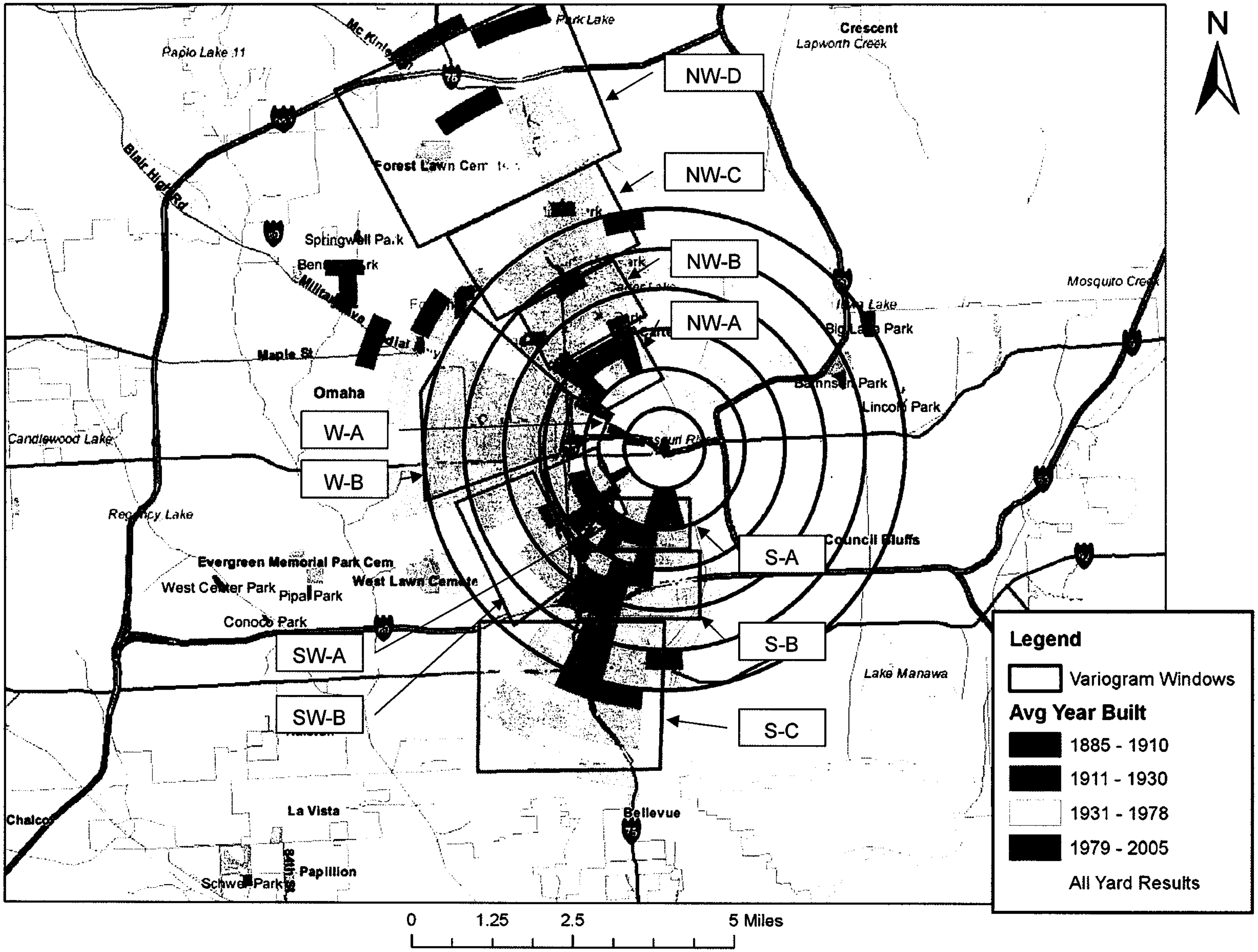


Figure 3. Variogram Windows and Average Construction Year of Structures in Investigated Properties Displayed within 1-km Radial Transects from the Smelter

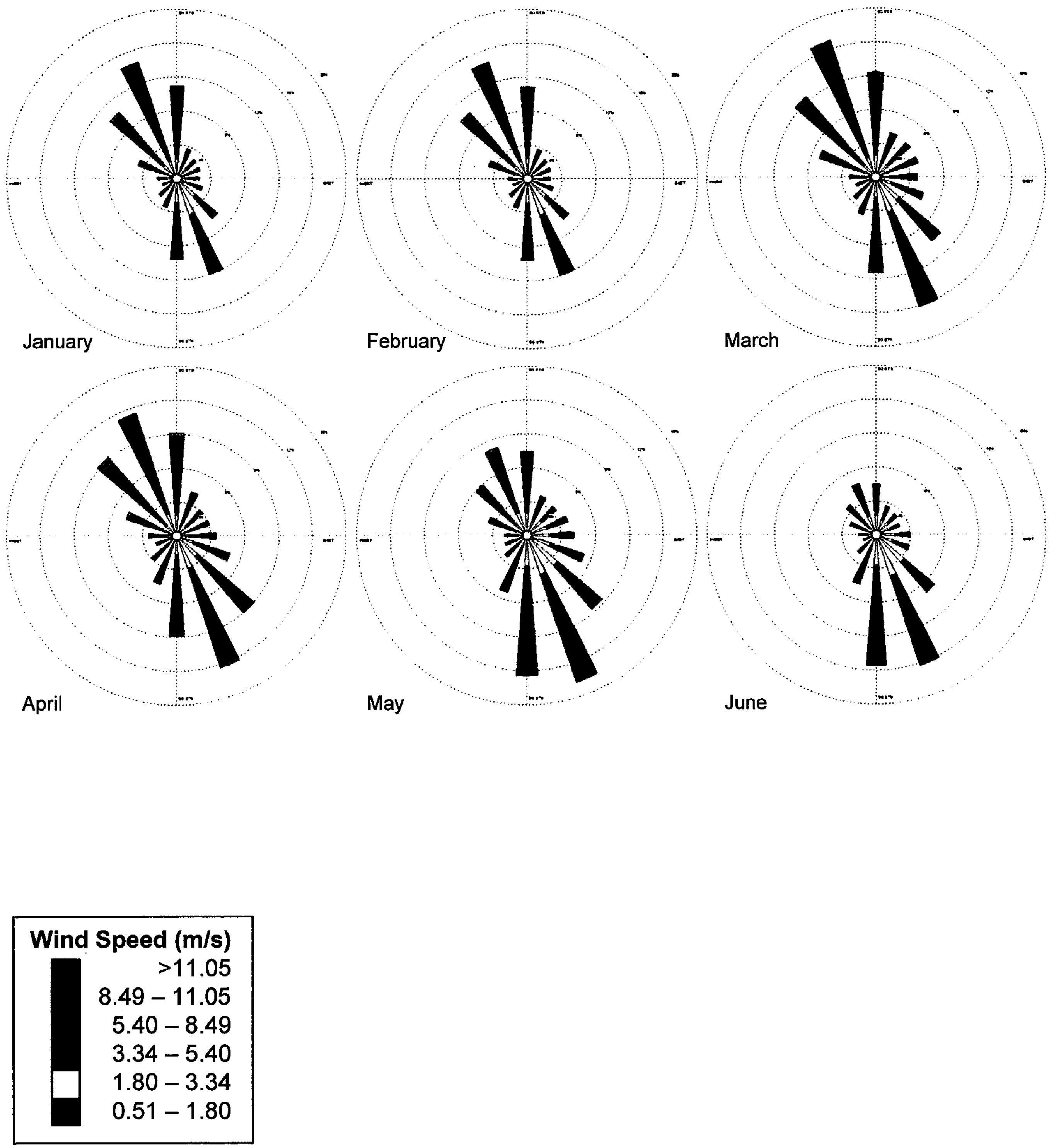


Figure 4. Monthly Wind Rose Diagrams
(a) January through June

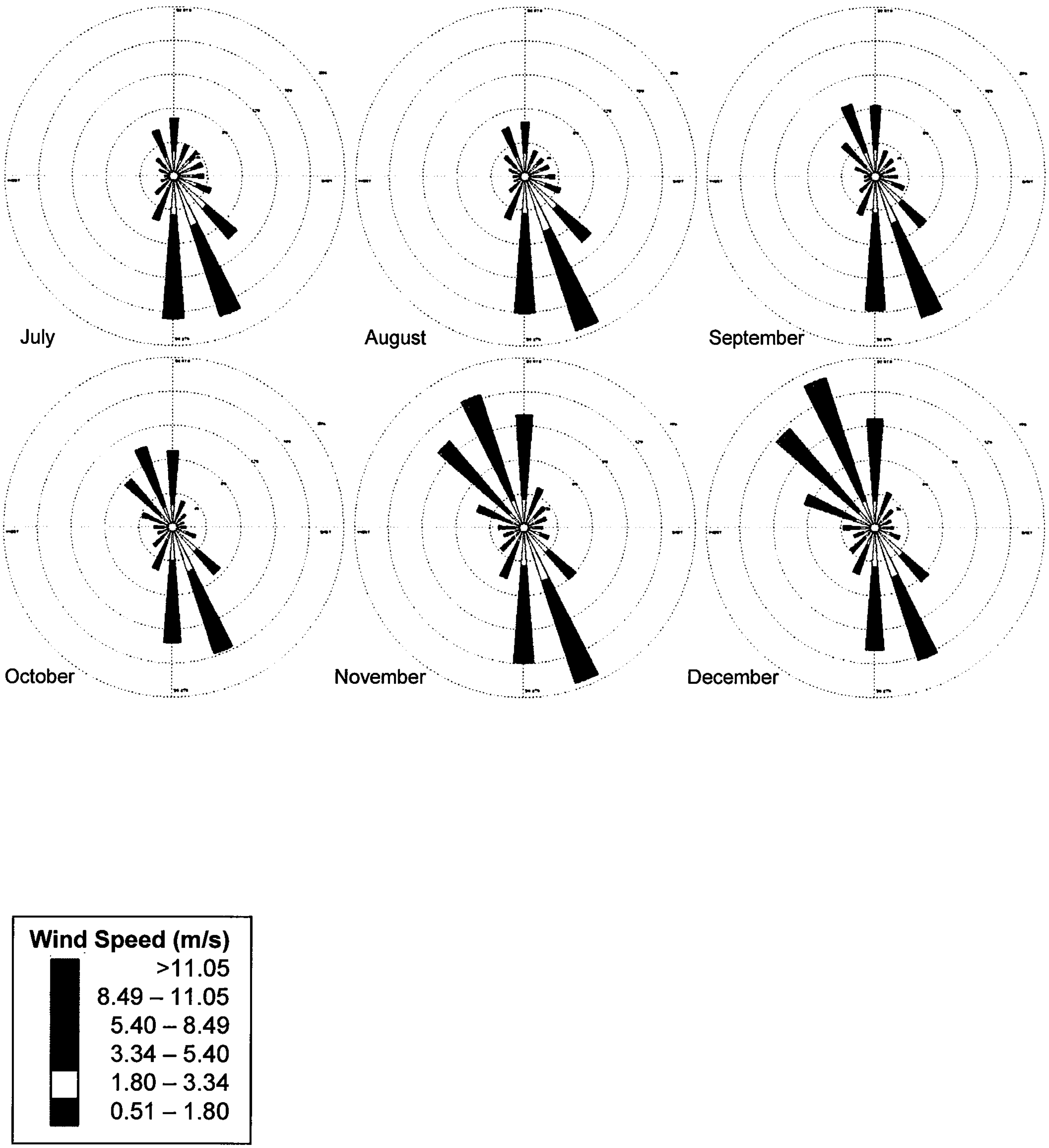
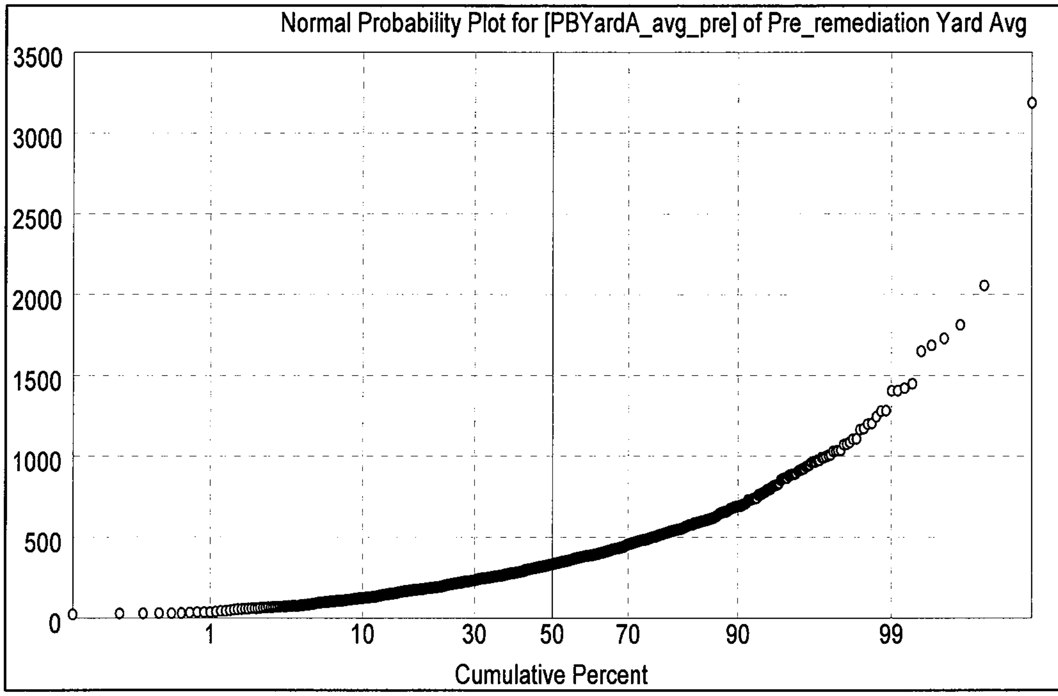


Figure 4. Monthly Wind Rose Diagrams
(b) July through December



Count	952
Minimum	22.0
Maximum	3188.0
Sum	368841.0
Mean	387.438
Median	333.0
StdDev	272.719
Variance	74375.64
Skewness	2.638781
Kurtosis	15.54407
95 UCL	401.978

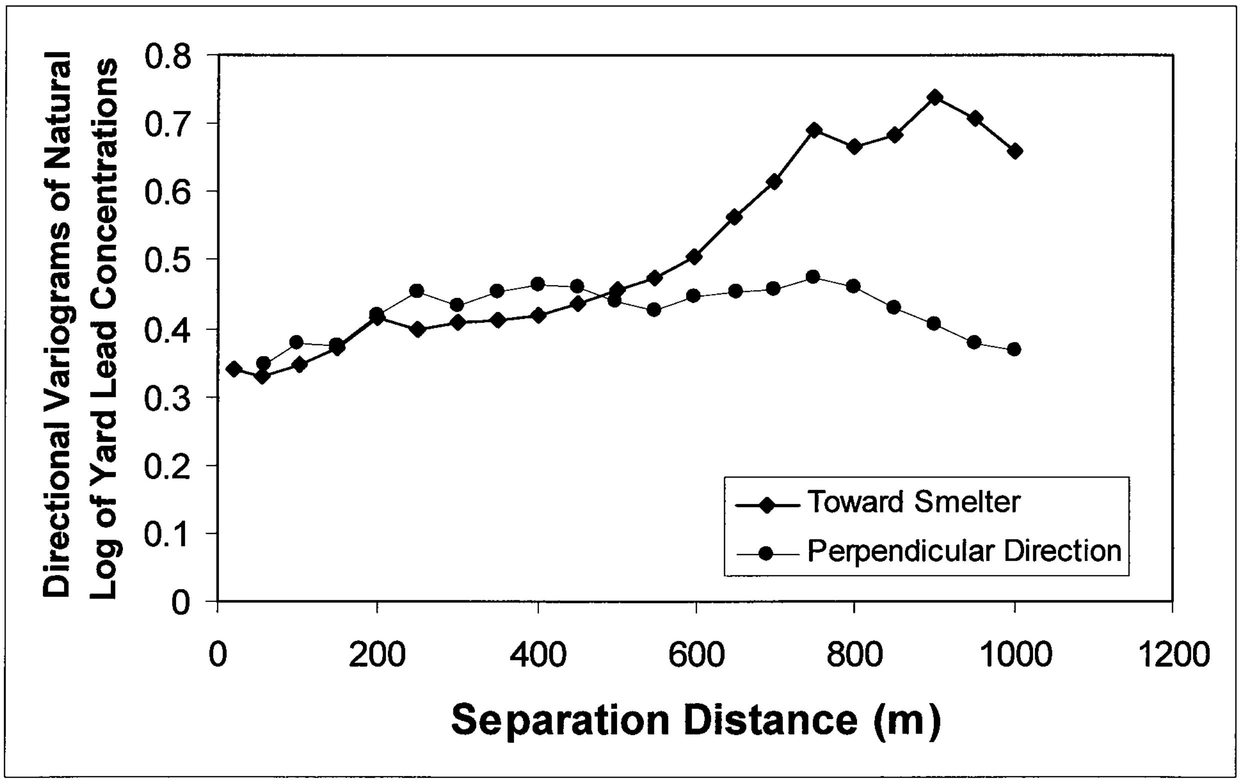
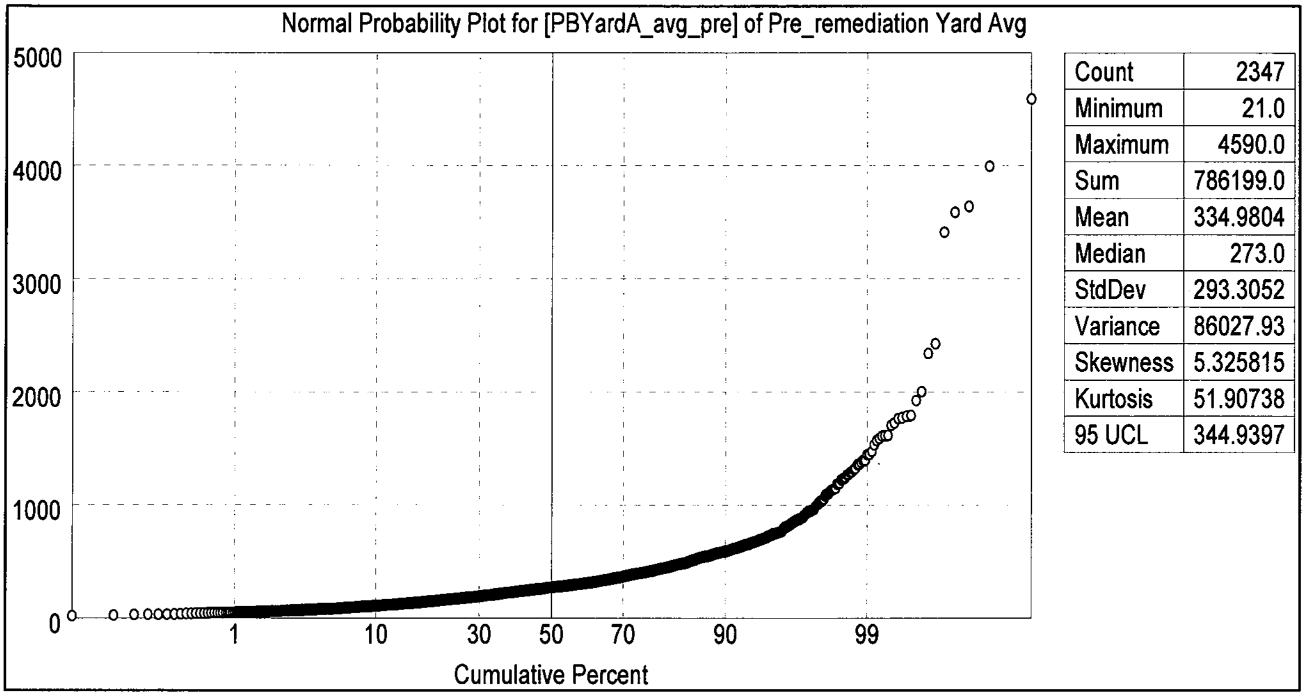


Figure 5a. Probability Plot and Directional Variograms of Yard Lead Data Window NW-A



Count	2347
Minimum	21.0
Maximum	4590.0
Sum	786199.0
Mean	334.9804
Median	273.0
StdDev	293.3052
Variance	86027.93
Skewness	5.325815
Kurtosis	51.90738
95 UCL	344.9397

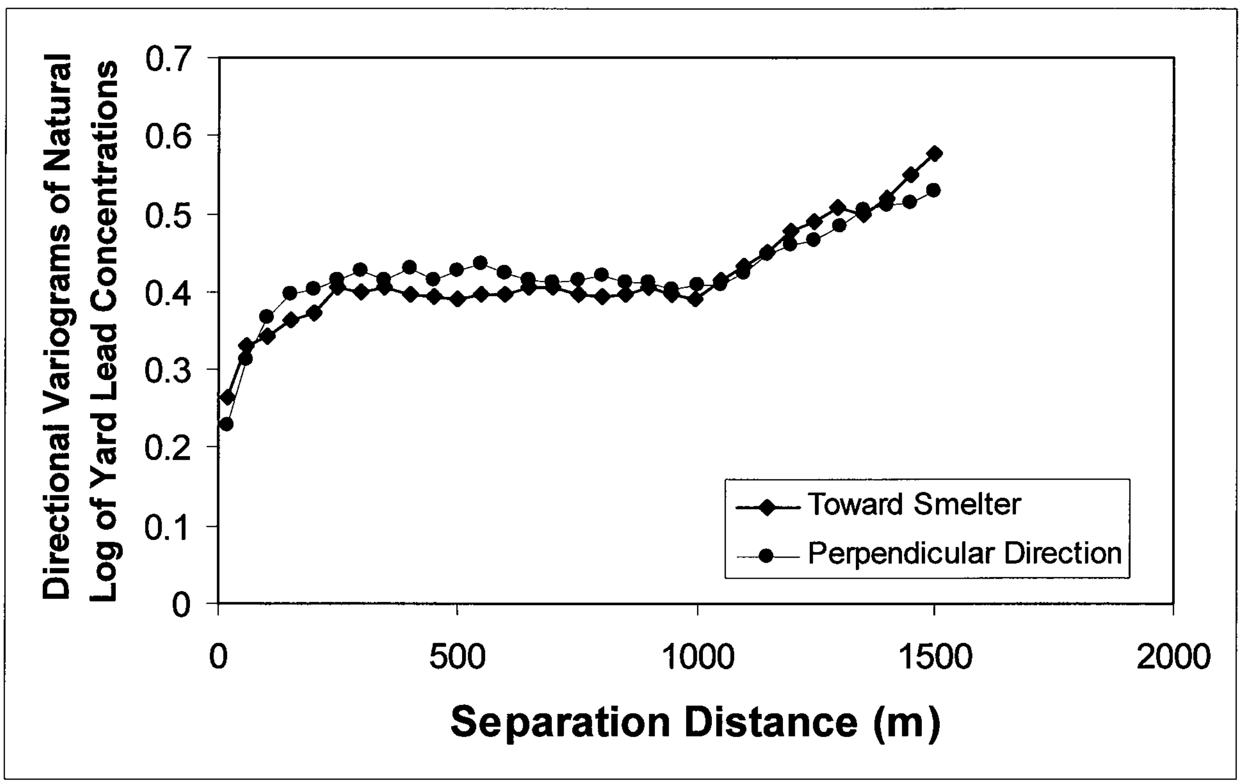
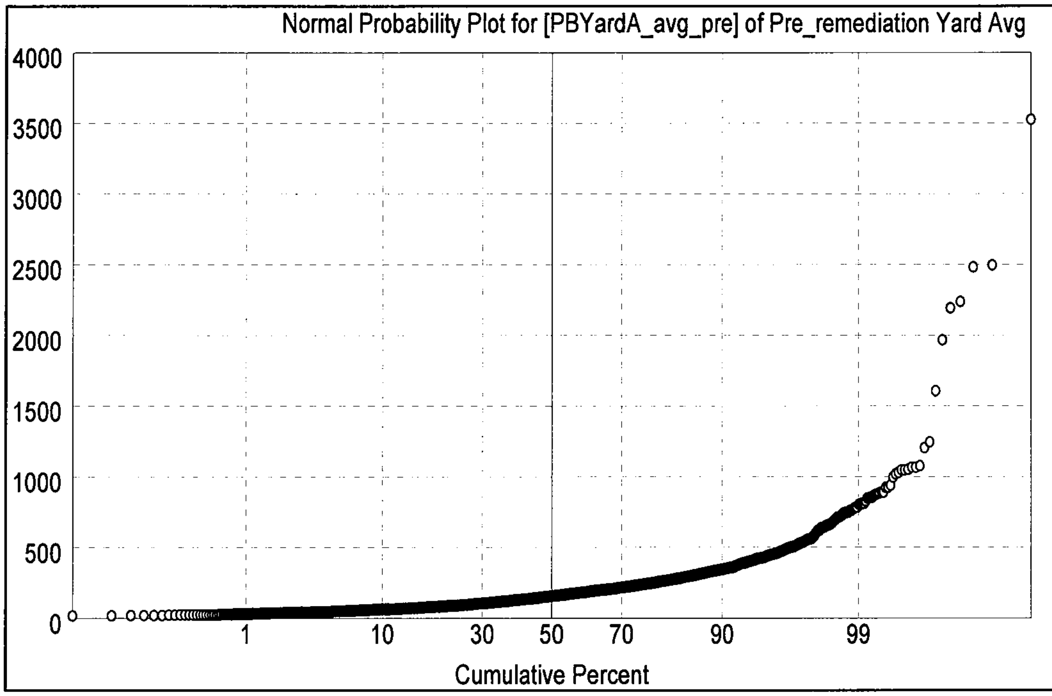


Figure 5b. Probability Plot and Directional Variograms of Yard Lead Data Window NW-B



Count	3650
Minimum	19.0
Maximum	3527.0
Sum	705099.0
Mean	193.1778
Median	158.0
StdDev	170.1306
Variance	28944.43
Skewness	6.04031
Kurtosis	76.37928
95 UCL	197.8102

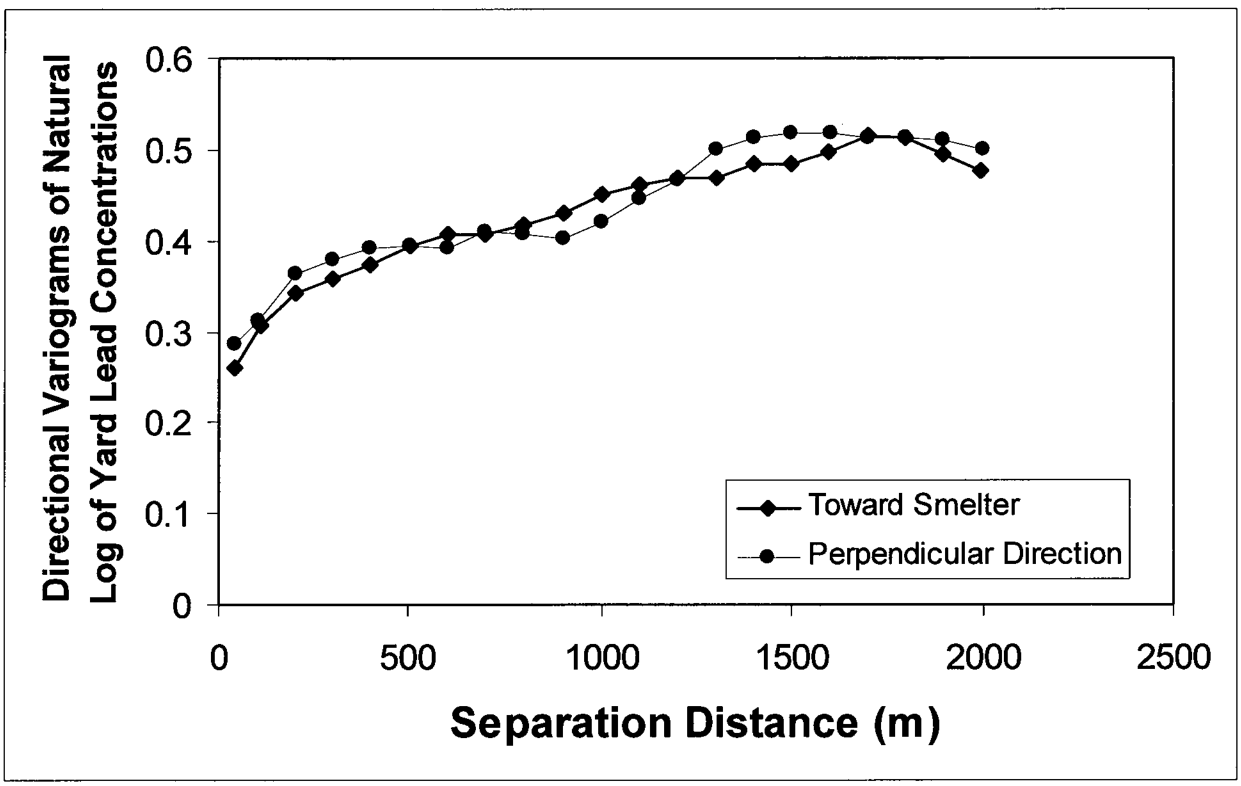
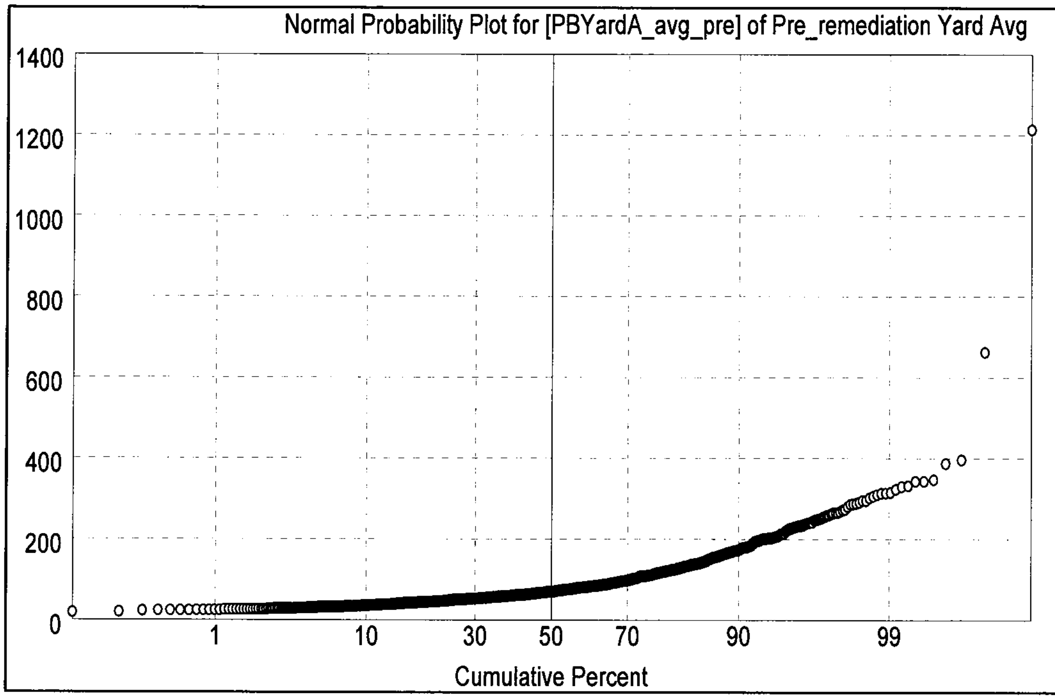


Figure 5c. Probability Plot and Directional Variograms of Yard Lead Data Window NW-C



Count	1070
Minimum	19.0
Maximum	1214.0
Sum	98444.0
Mean	92.00374
Median	71.0
StdDev	72.16042
Variance	5207.126
Skewness	5.022077
Kurtosis	58.9129
95 UCL	95.63262

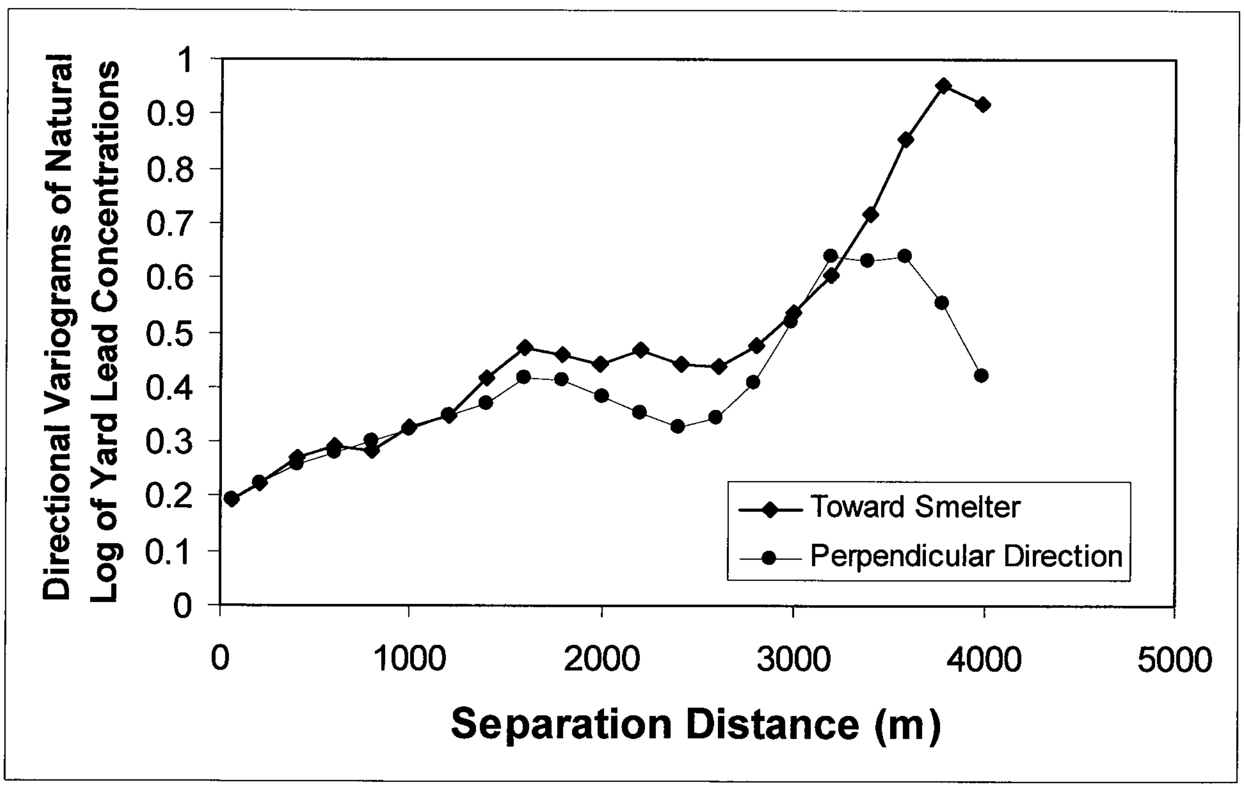
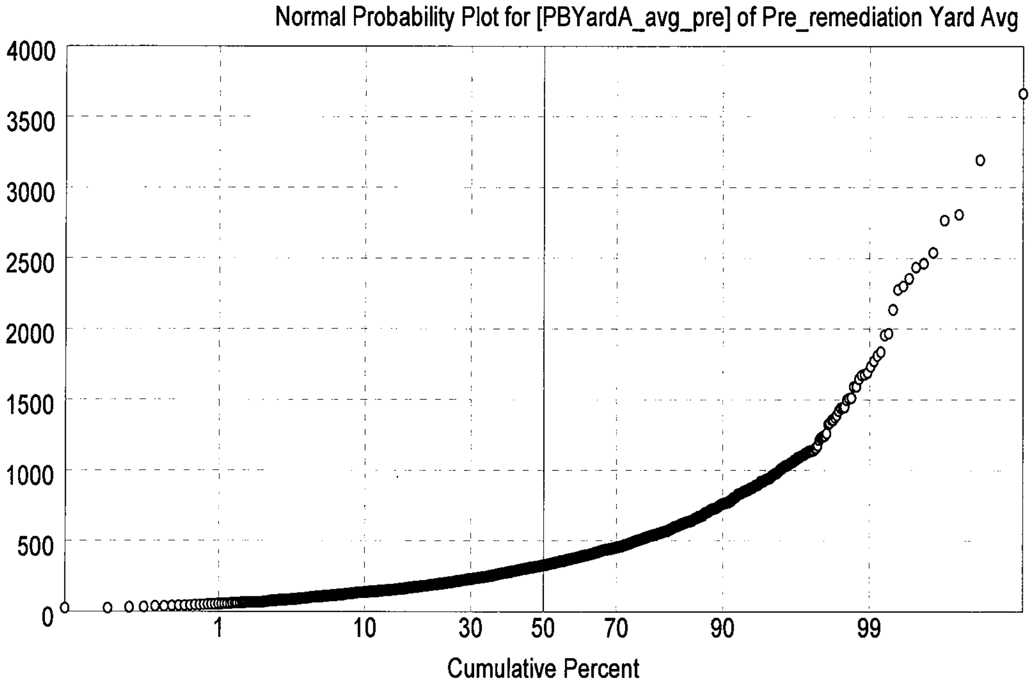


Figure 5d. Probability Plot and Directional Variograms of Yard Lead Data Window NW-D



Count	1673
Minimum	24.0
Maximum	3665.0
Sum	687364.0
Mean	410.8571
Median	330.0
StdDev	330.0458
Variance	108930.2
Skewness	3.229499
Kurtosis	17.79347
95 UCL	424.1308

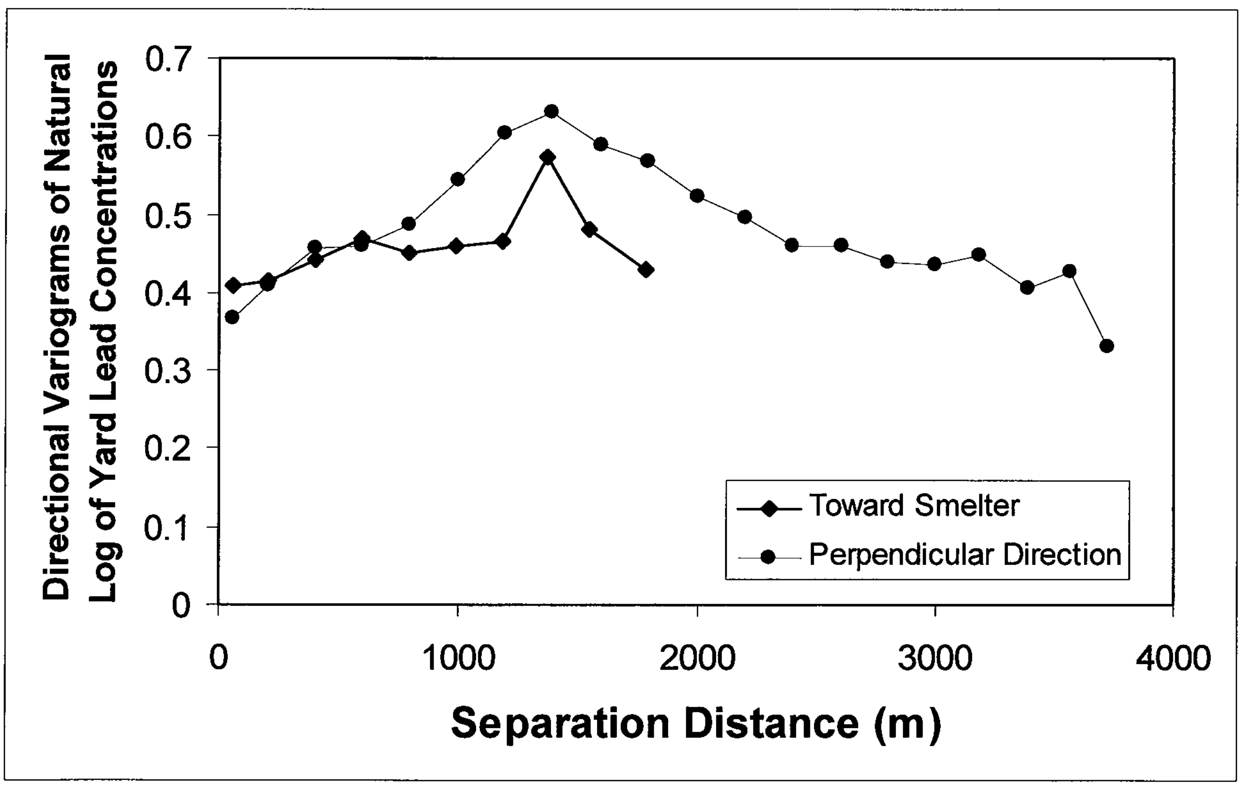
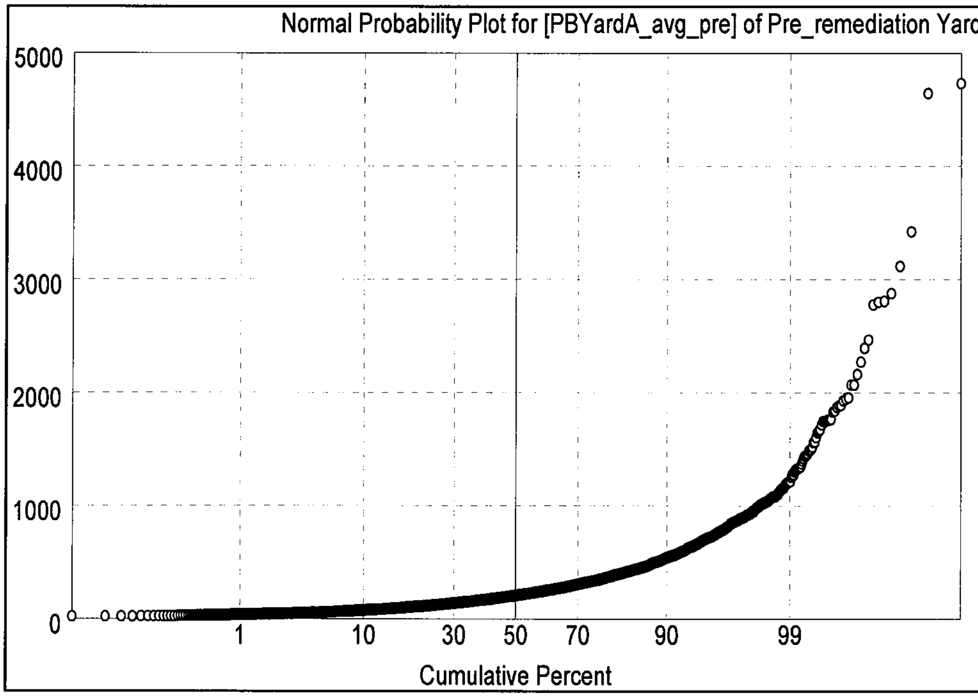


Figure 5e. Probability Plot and Directional Variograms of Yard Lead Data Window W-A



Count	5881
Minimum	22.0
Maximum	4734.0
Sum	1.640765E+06
Mean	278.9942
Median	209.0
StdDev	264.2639
Variance	69835.4
Skewness	4.659759
Kurtosis	44.93769
95 UCL	284.6628

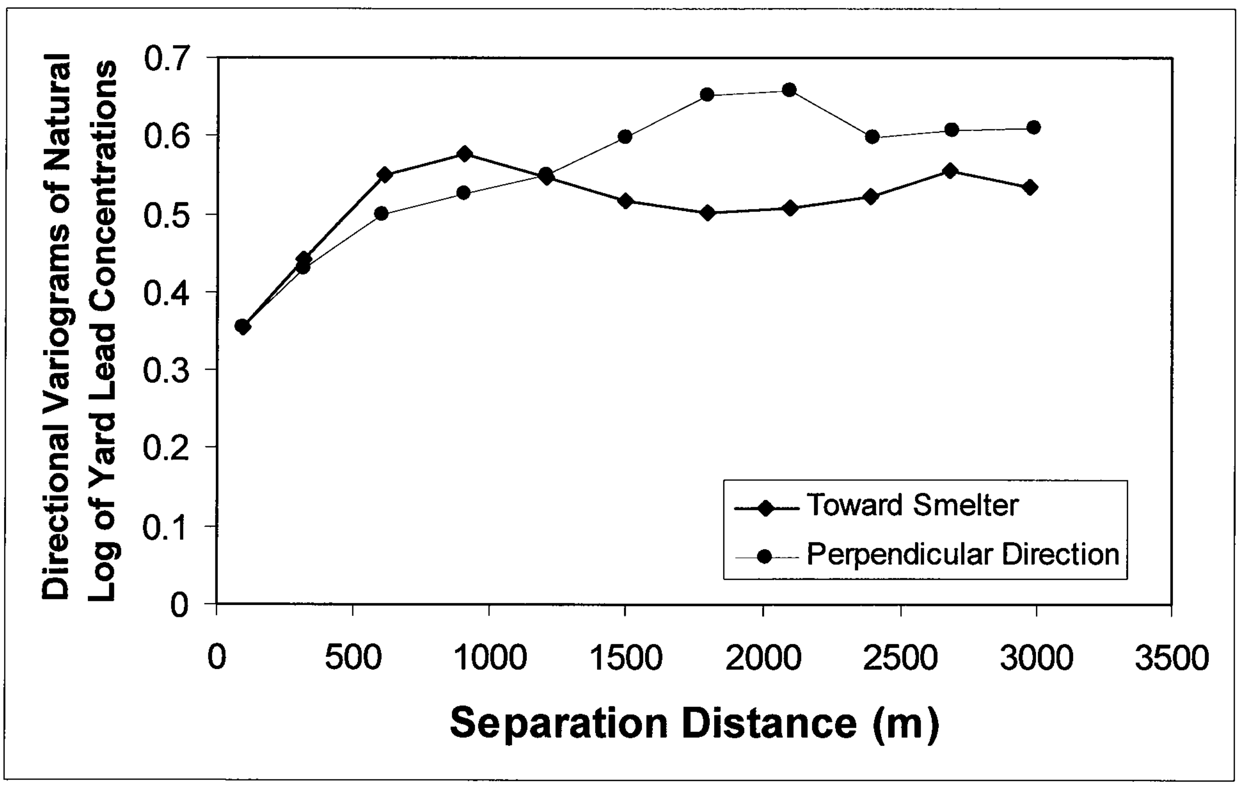
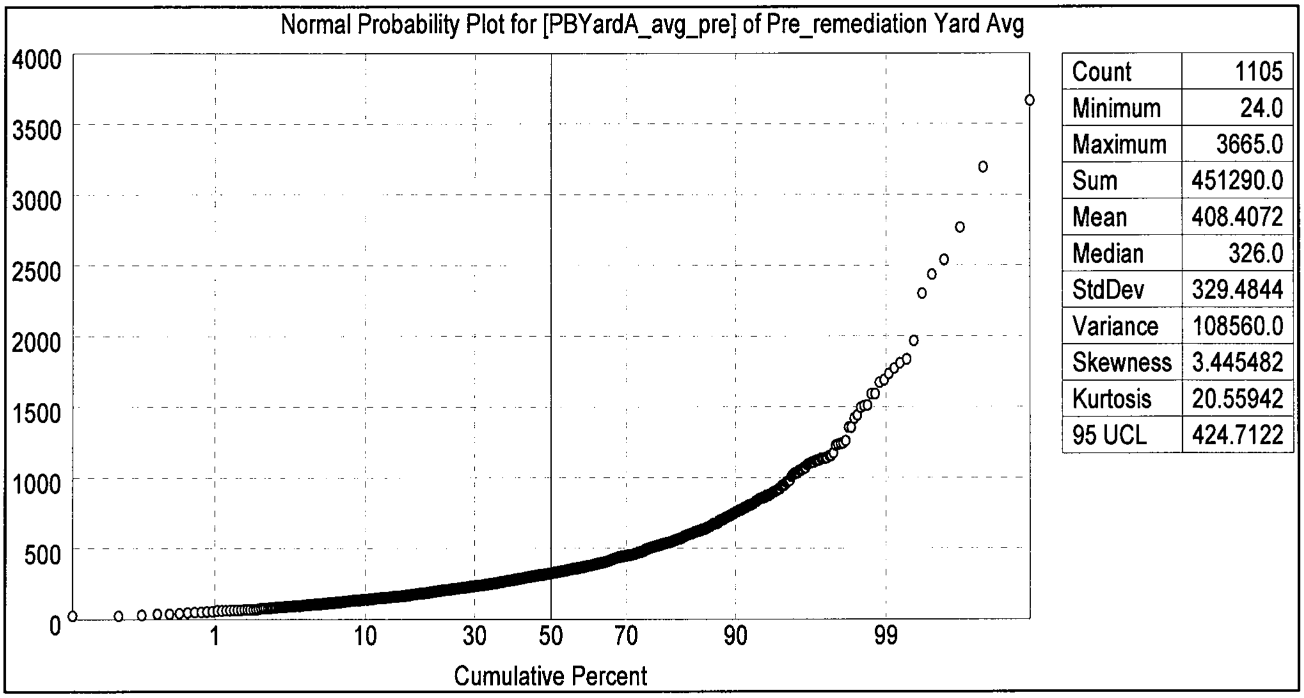


Figure 5f. Probability Plot and Directional Variograms of Yard Lead Data Window W-B



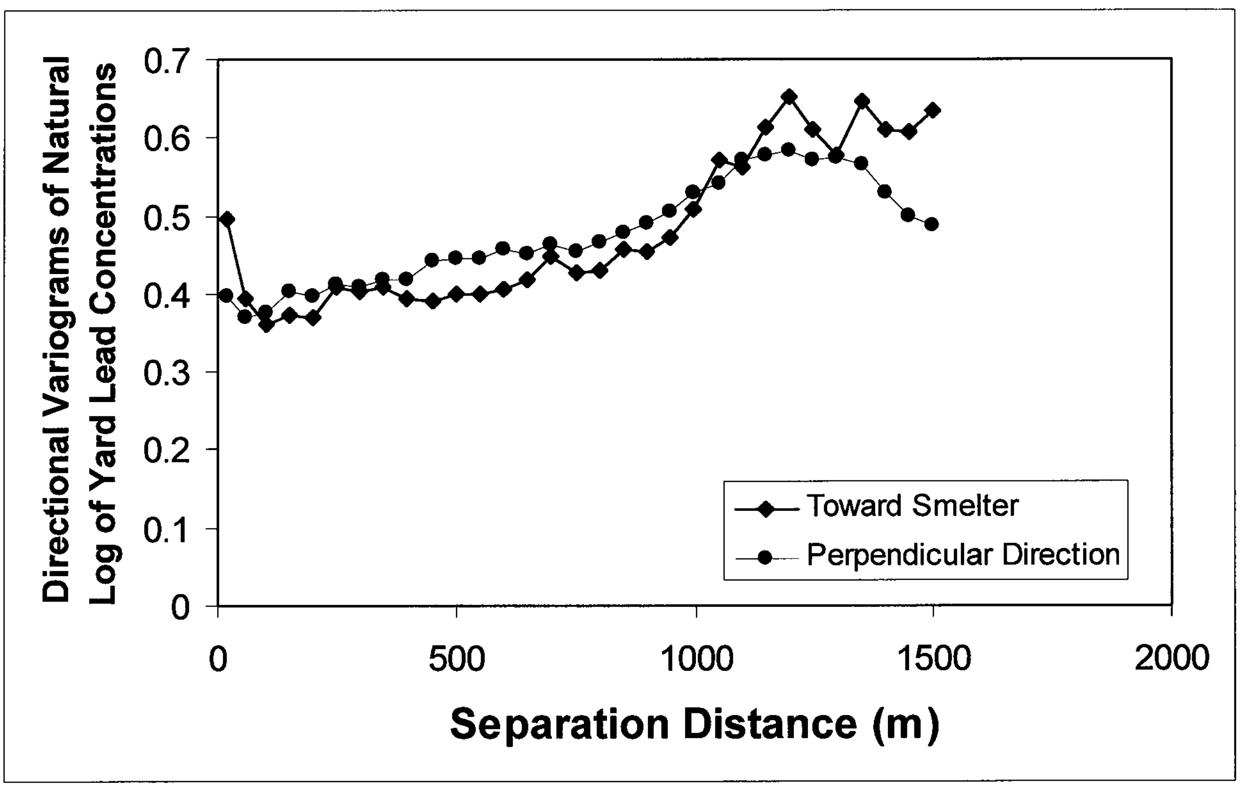
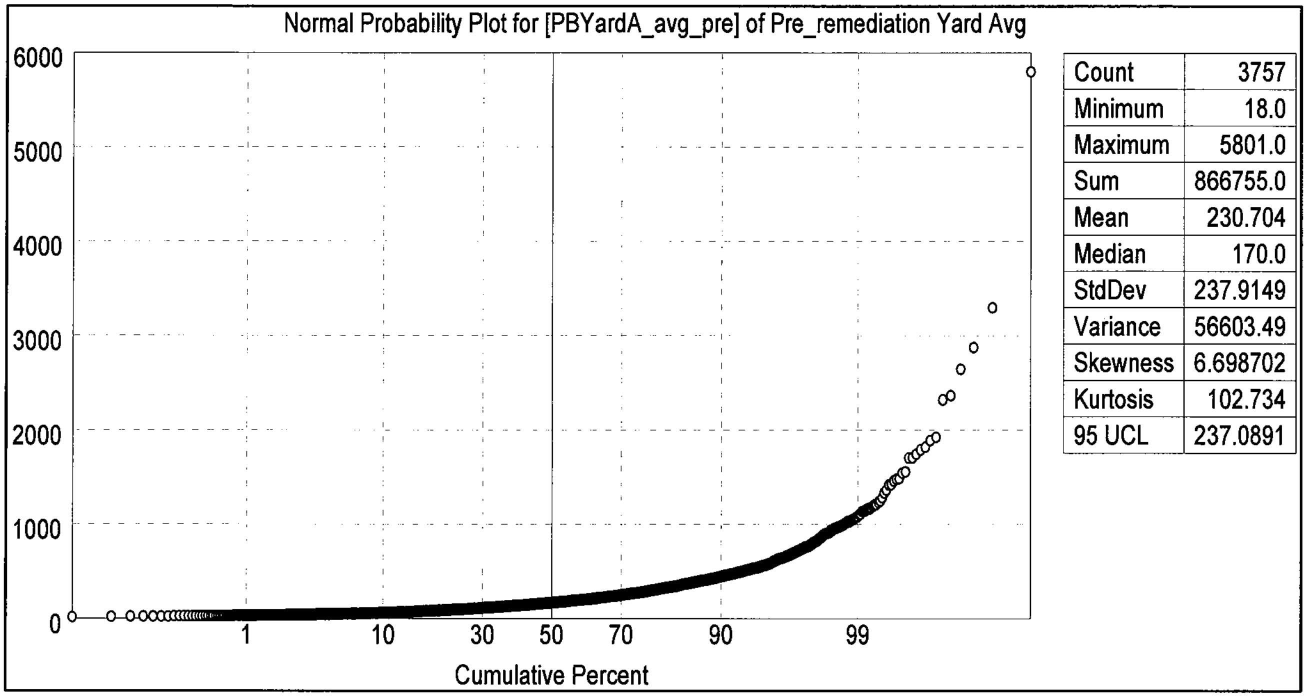


Figure 5g. Probability Plot and Directional Variograms of Yard Lead Data Window SW-A



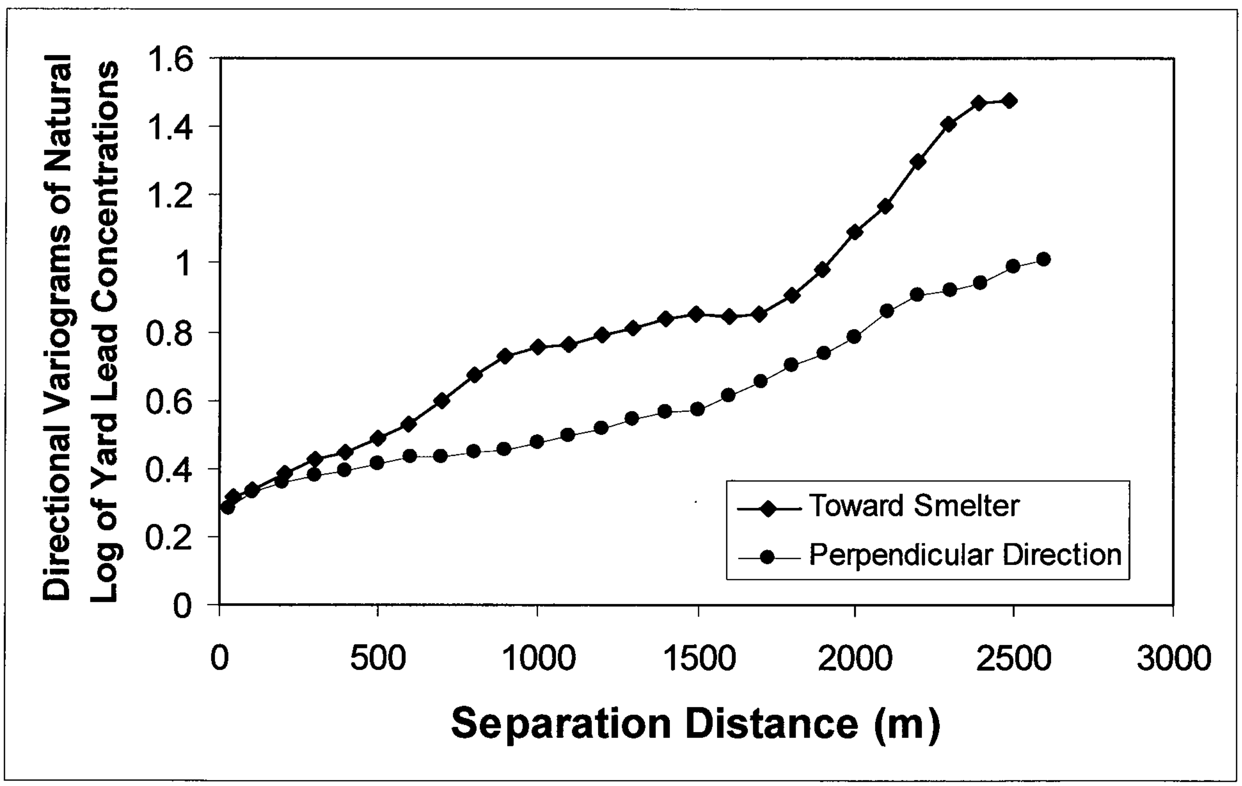
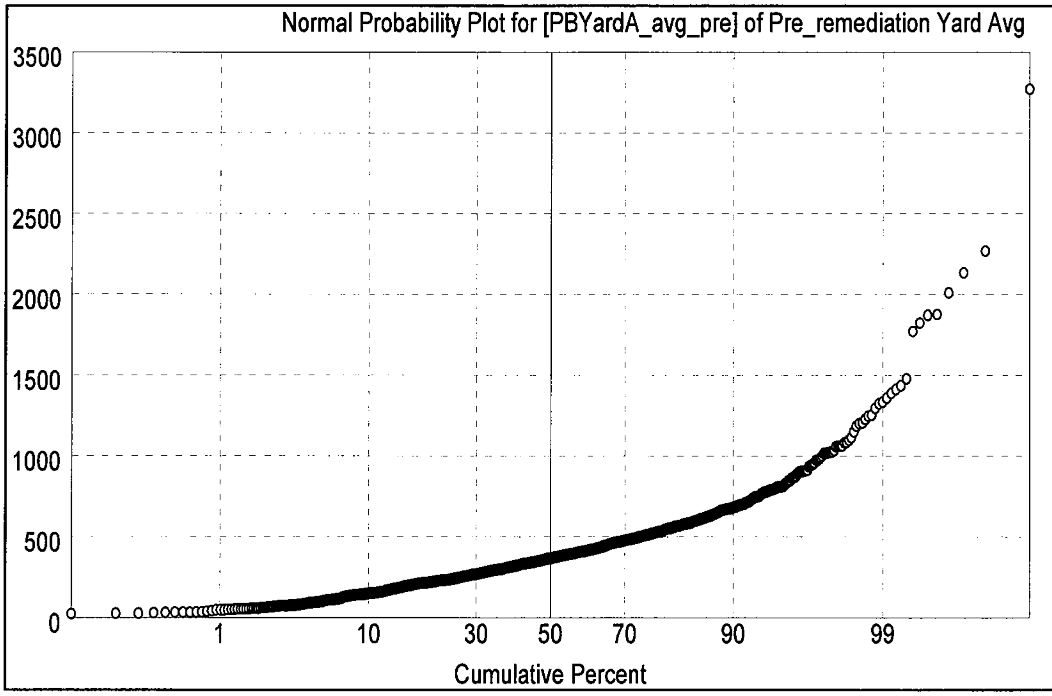


Figure 5h. Probability Plot and Directional Variograms of Yard Lead Data Window SW-B



Count	1337
Minimum	24.0
Maximum	3272.0
Sum	547891.0
Mean	409.7913
Median	367.0
StdDev	262.5675
Variance	68941.67
Skewness	2.776859
Kurtosis	17.40028
95 UCL	421.6038

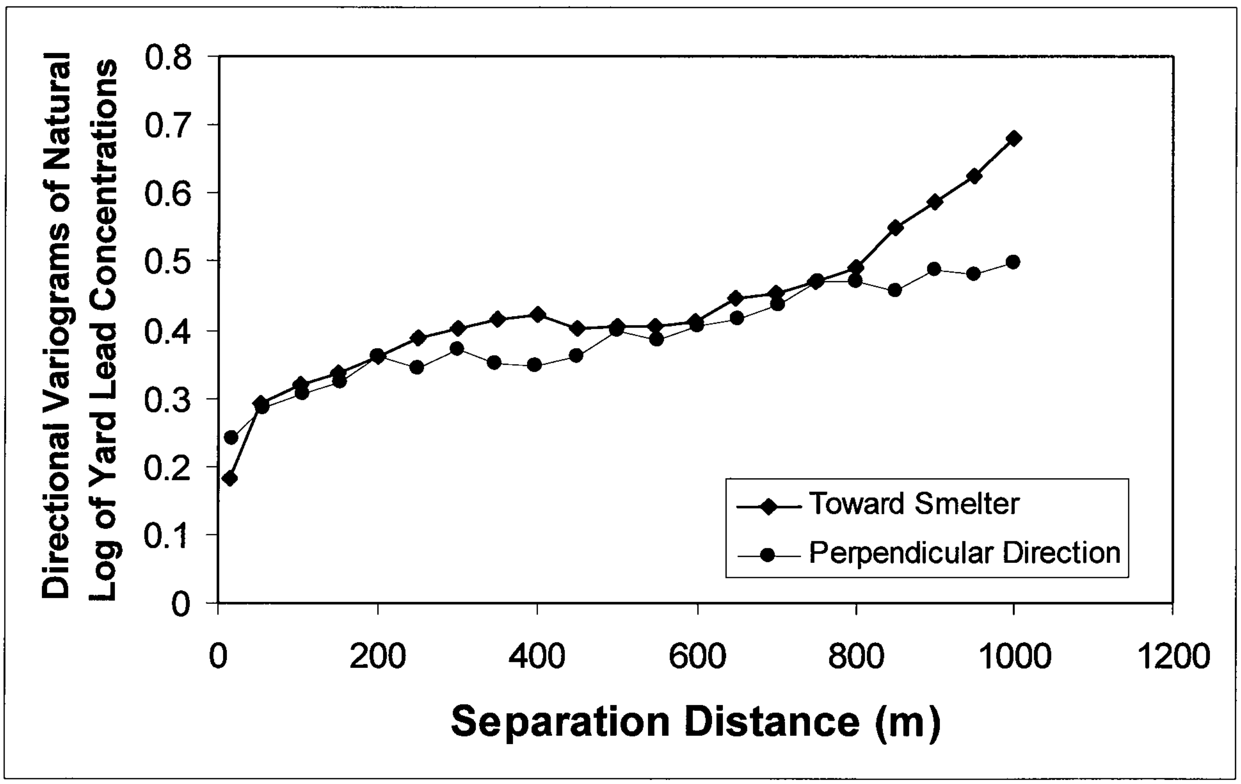
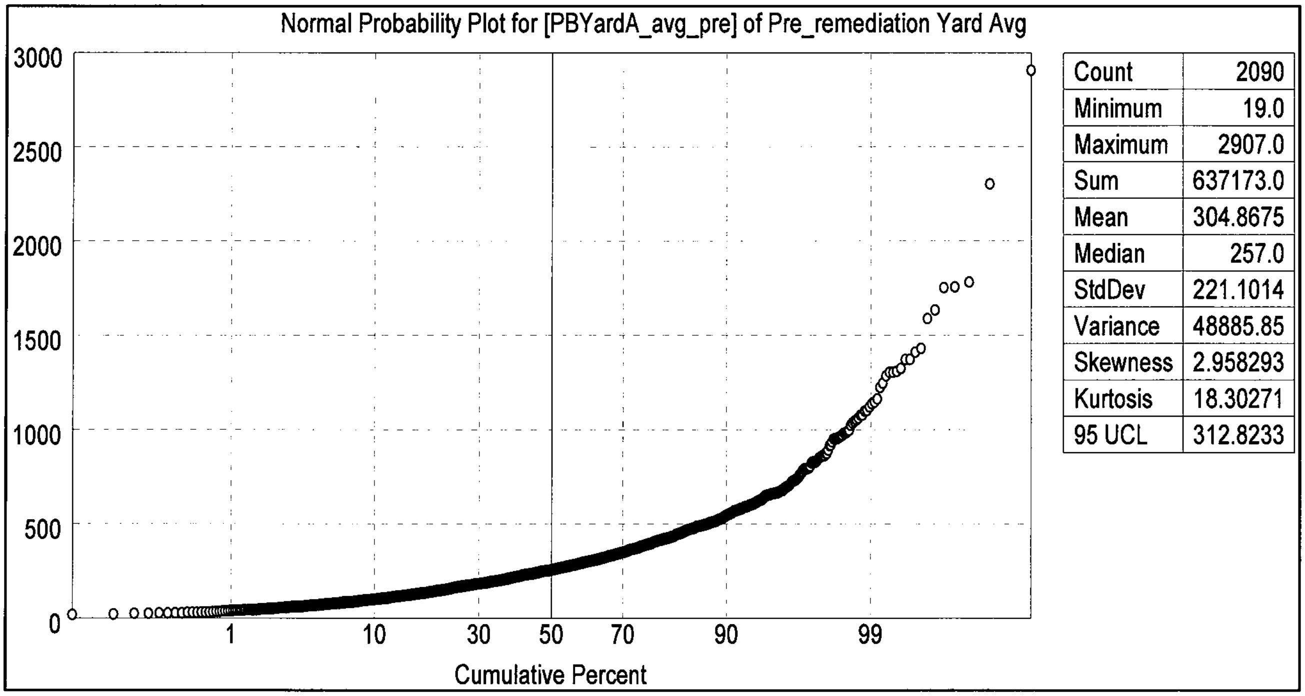


Figure 5i. Probability Plot and Directional Variograms of Yard Lead Data Window S-A



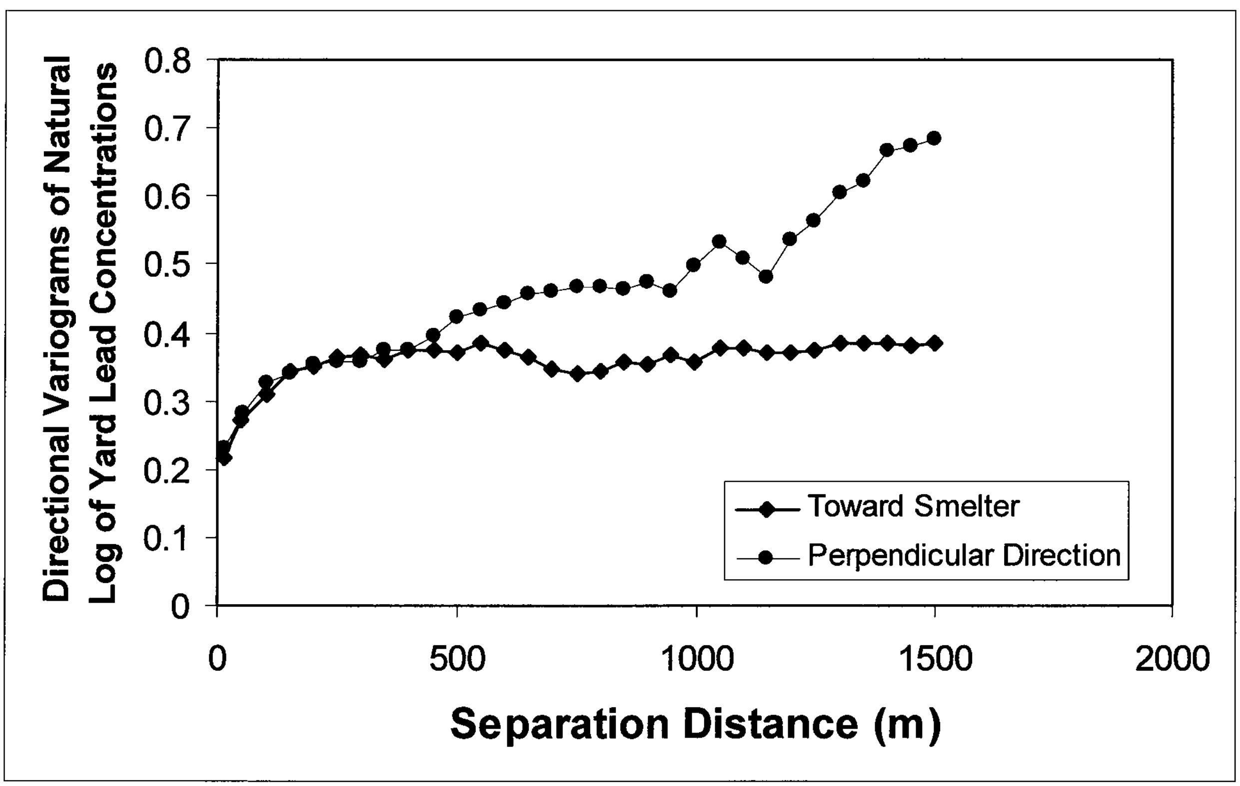
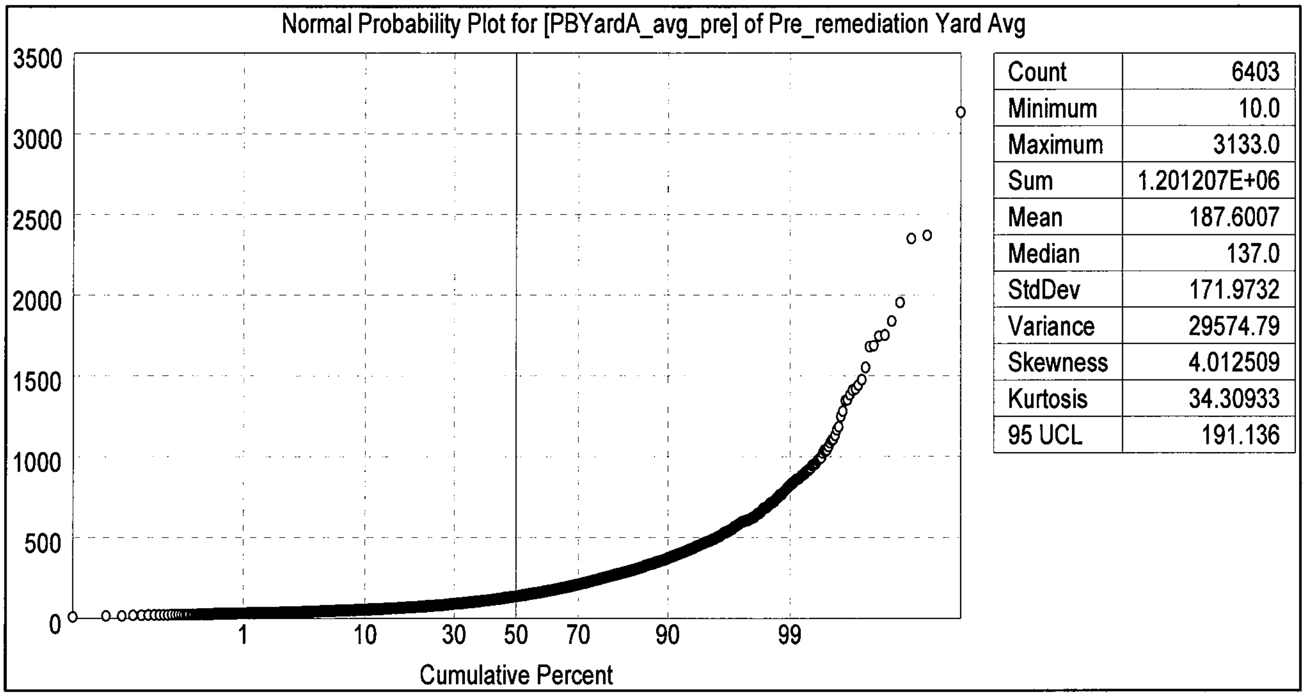


Figure 5j. Probability Plot and Directional Variograms of Yard Lead Data Window S-B



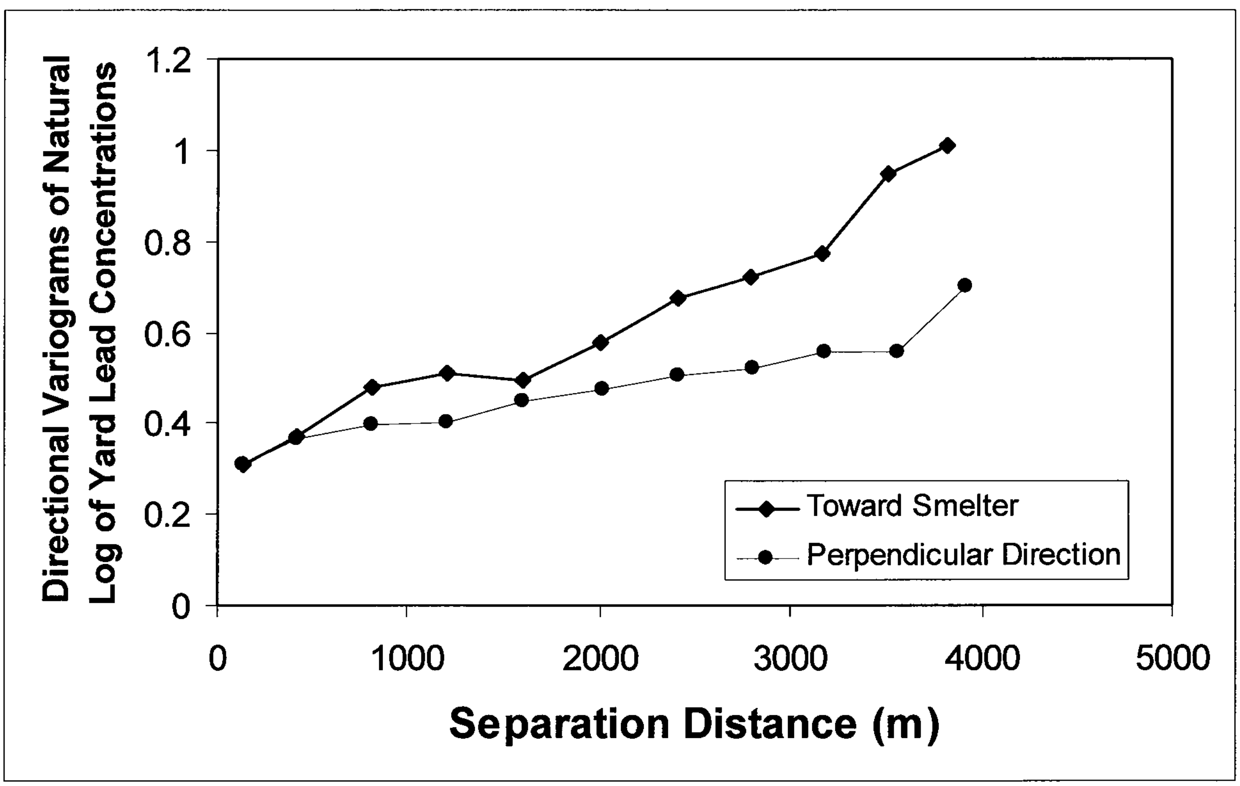


Figure 5k. Probability Plot and Directional Variograms of Yard Lead Data Window S-C

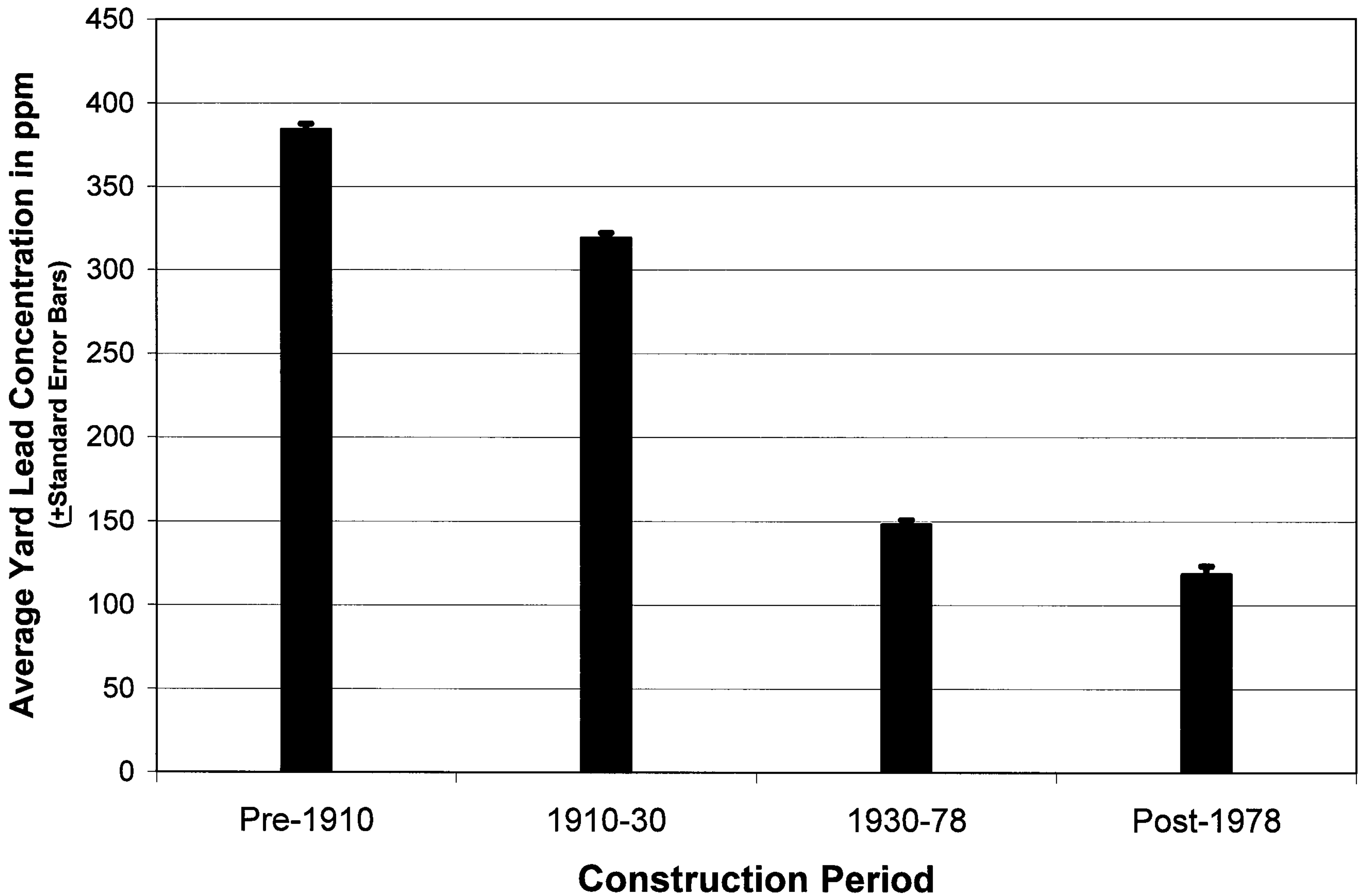


Figure 6. Age of Structures versus Yard Lead Data

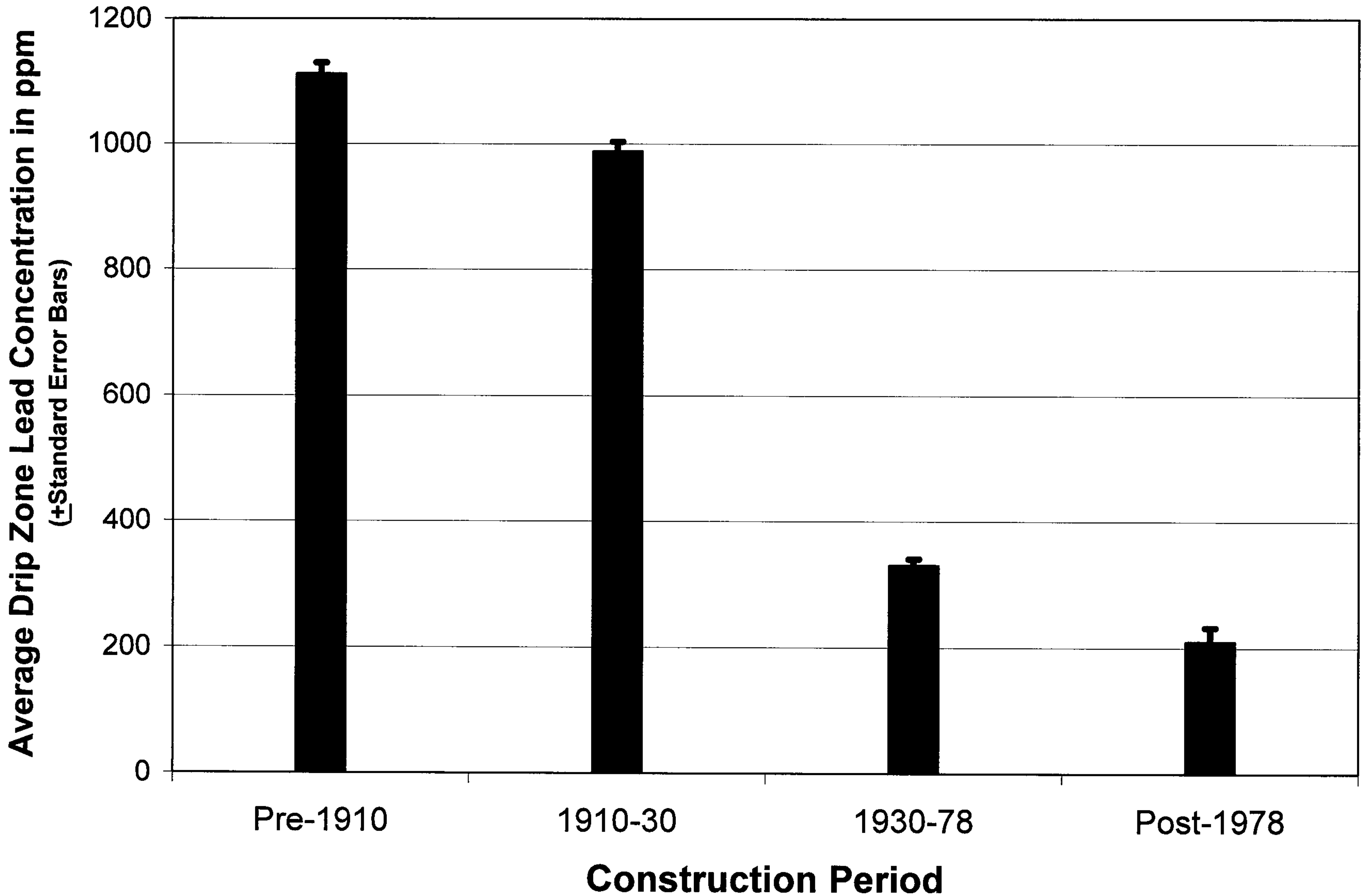


Figure 7. Age of Structures versus Drip Zone Lead Data

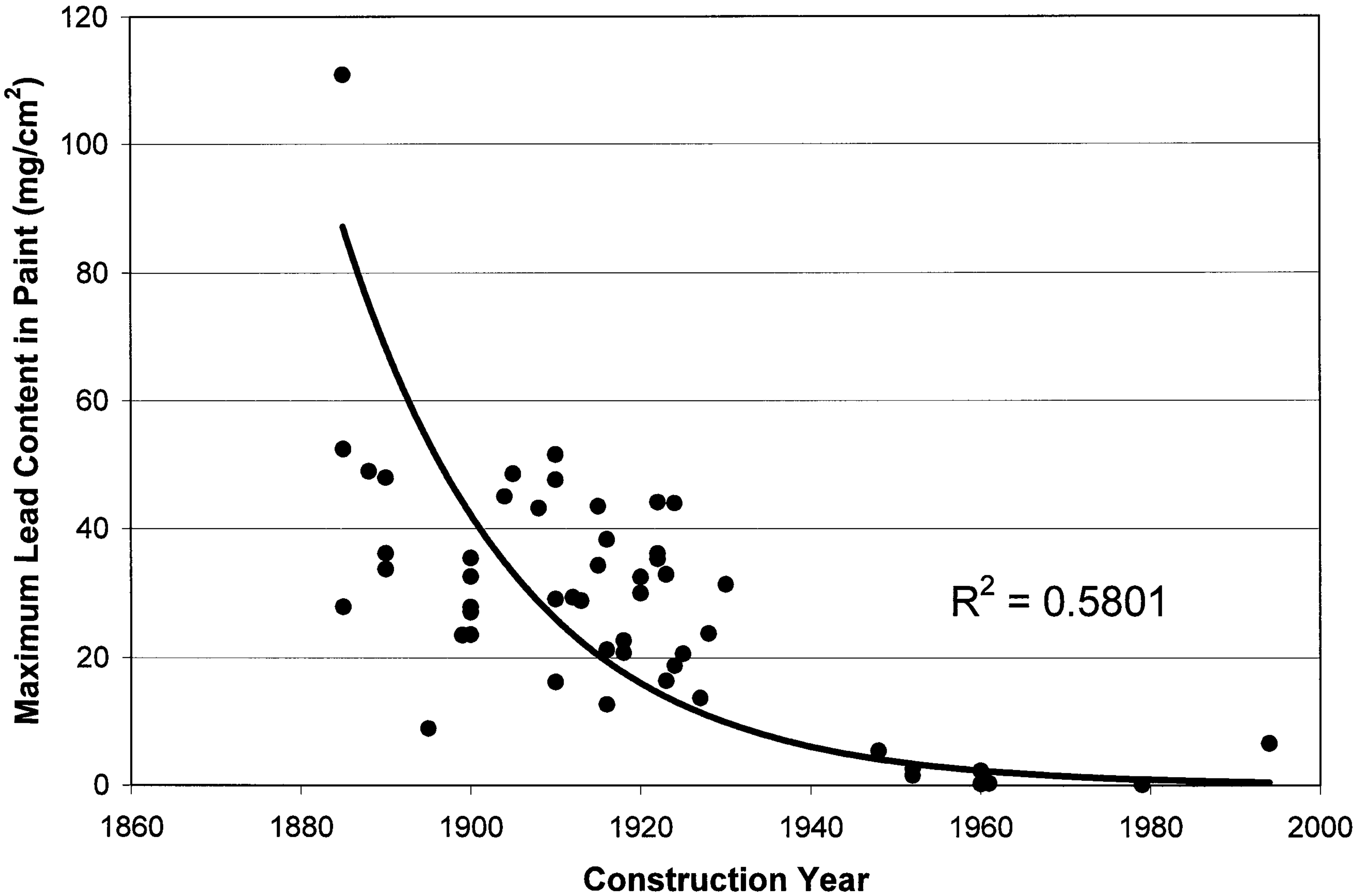


Figure 8. Age of Structures versus Lead Paint Data

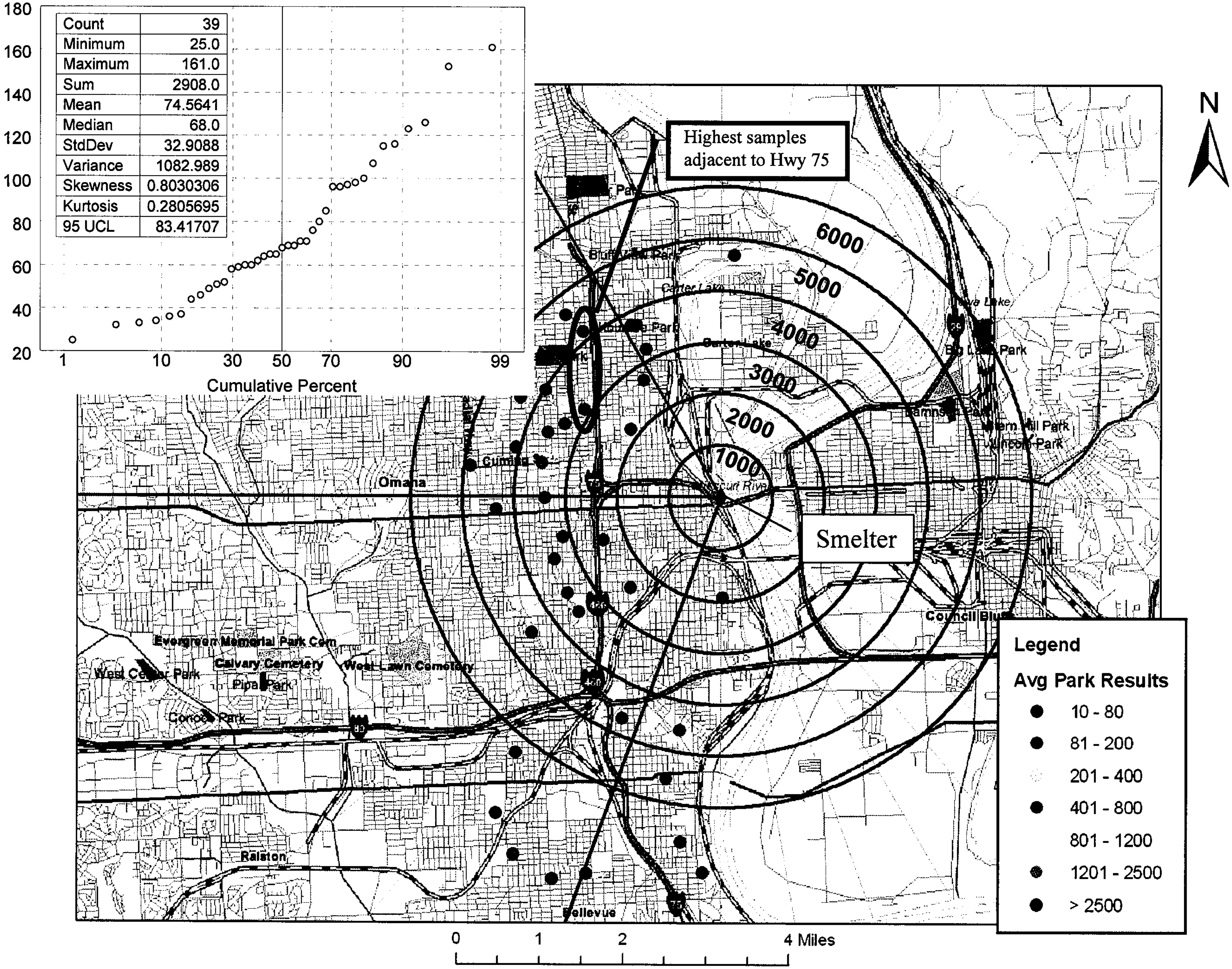


Figure 9. Park Lead Data